COMPLIMENTARY

EXPERIMENTAL HUSBANDRY FARMS

EXPERIMENTAL HORTICULTURE STATIONS

PROGRESS REPORT

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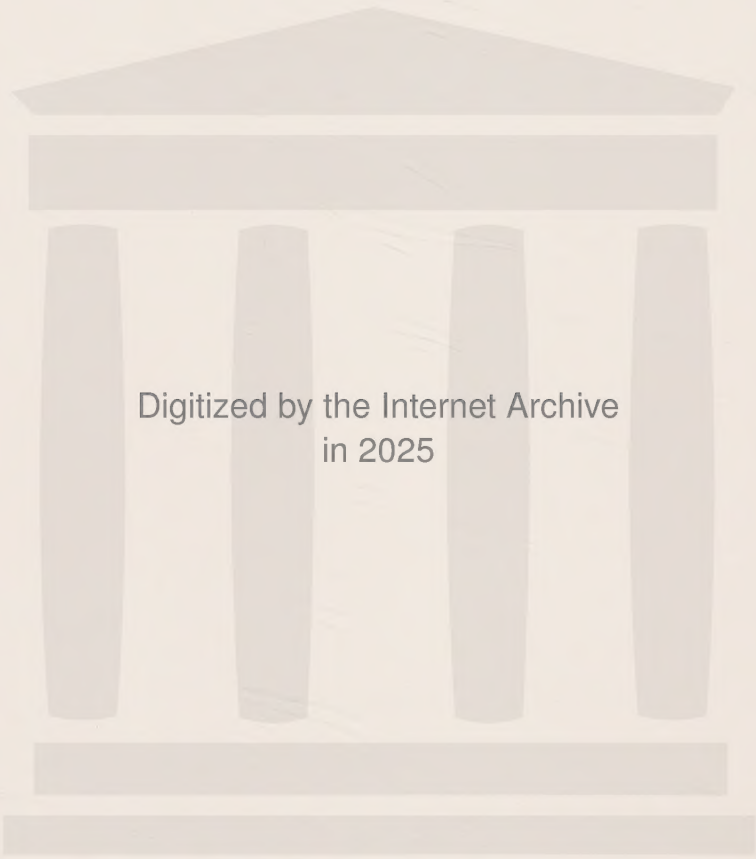

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MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

NATIONAL AGRICULTURAL ADVISORY SERVICE

Experimental Husbandry Farms and Experimental Horticulture Stations

PROGRESS REPORT
1963

LONDON
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Introduction

This is the fourth Progress Report from the Husbandry Farms and Horticulture Stations and, as indicated in the Foreword to the first one, a selection only has been made of topics of special interest from the large number of experiments in progress. The aim is to cover the whole field of the investigations over a period of a few years and interim statements will be made on the long-term experiments from time to time.

This Report is one of several accounts of the work of the Experimental Centres. Each Centre is producing an annual report designed mainly for farmers and horticulturists in their own areas and these can be obtained on application to the Director whose address is listed on pages 68–70. The full account of completed experiments including all necessary supporting data is published in *Experimental Husbandry* or *Experimental Horticulture*.

Results from Recent Experiments

FERTILITY FROM LEYS

P. N. Harvey

Director, Gleadthorpe Experimental Husbandry Farm

Alternating crops and grass is a long established practice in the wetter districts where the climate favours quick and certain growth of newly sown swards. But it was not until good grass and clover seeds became available and the value of fertilizer for grass was more clearly understood, that alternate ley and arable shifts could be worked successfully in the drier areas.

As a system of farming it is flexible, and leys are likely to be more productive for three or four years than any but the best permanent grass: other advantages are that new grass is healthier for stock, and weeds of both grass and arable land, are discouraged.

But in times of falling profit margins, can the arable farmer afford to tie up a proportion of his acreage in grass from which a cash return can only be realized through relatively unprofitable livestock enterprises? How much better do crops yield after a period in grass, and does the gain justify the reduced cash return per acre from the part of the farm which is temporarily lost to arable cropping?

To answer these questions, the production from land continuously in arable cultivation must be compared with similar land farmed on a system in which a sequence of arable crops alternates with a period down to grass. This was the plan of the ley/arable experiment which was started at Rothamsted in 1949 and, in order to obtain comparable data under a wider range of conditions, experiments on similar lines were begun at four Experimental Husbandry Farms in 1951 and at two others in 1952.

Soil and rainfall conditions at the six Farms are as follows:

Farm	*County*	*Soil type*	*Average annual rainfall (in.)*
Boxworth	Cambs.	Boulder clay	22
Bridget's	Hants.	Chalky loam	30
Gleadthorpe	Notts.	Light sand with many stones	24
High Mowthorpe	Yorks.	Medium loam over chalk	30
Rosemaund	Hereford	Heavy clay—medium clay loam	26
Trawscoed	Cards.	Medium stony loam	45

The first results of the Rothamsted experiment have recently been reported (Rothamsted Annual Report 1961 pp. 173–180) and they suggest that, on a soil not easily subject to physical deterioration, arable crop yields have not been materially improved by a preceding three year period down to grass as compared with normal arable cropping. In some cases, yields were lower after arable crops, but this difference could be made good by the use of additional fertilizer. The purpose of the present article is to summarize the information which has so far resulted from the experiments at the Husbandry Farms.

The Principles Underlying the Experimental Plan

There are three principal reasons why a period under grass could benefit crops, namely, an improvement in soil fertility, an improvement in the physical condition of the soil and better control of disease.

An improvement in soil fertility. While down to grass, a field accumulates fertility from legumes in the sward and from the dung and urine of the grazing animal.

Experimental evidence suggests that any improvement in crop yield after the grass is broken up is probably due to increased nitrogen residues. Nitrogen supply is certainly a critical factor and, for this reason, all crops in the experiment under review were grown at two levels of nitrogen use. The inclusion in the experiment of a comparison between the grazed ley and a similar sward where all the produce was cut and removed, gives a measure of the contribution of the grazing animal to soil fertility. Since the lucerne ley has acquired a special reputation on light sand and chalk soils for building up fertility, a lucerne ley for conservation was also provided for in the experimental plan.

An improvement in the physical condition of the soil. The accepted explanation is that the incorporation of a turf in the soil improves crumb structure and this in turn makes clay land easier to work and light land less liable to dry out.

Better control of diseases. This refers especially to soil borne cereal diseases and pests, such as cereal root eelworm. It was decided that the objective of the experiment should be to measure the contribution of the ley to soil fertility as distinct from the effect on subsequent crops of a reduced incidence of disease. The arable rotation chosen was therefore a good one in the sense that the proportion of cereal crops in the sequence was unlikely to create a disease situation which would confuse the treatment effects attributable to differences in soil fertility.

Cropping Sequences and Manurial Treatments Compared

With these considerations in mind the cropping was based on a six-course rotation, i.e., a "treatment" period of three years in grass/clover ley grazed or cut for conservation, lucerne for conservation, or arable crops, all followed by a "testing" sequence of potatoes, wheat and barley. In addition, there is a long ley treatment in which the land is down to grass for nine years followed by the same three test crops. The three arable crops, corresponding to the three years of ley, are sugar beet, barley and one-year clover, taken in that order. Thus the six-year all-arable rotation has only 50 per cent cereals in it, and the clover followed by potatoes constitutes a two-year break from cereals which is normally sufficient to keep soil-borne cereal diseases in check.

All six phases of the rotations are represented in duplicate every year and one third of the total number of plots was laid down in each of the first three years of the experiment.

Responses to dung and nitrogen are measured by giving the former at the rate of 14 tons/acre to half the plots cropped with potatoes each year, and by growing all crops (except the one-year clover ley of the arable rotation) at two levels of nitrogen.

The actual rates vary to some extent from farm to farm, but can be summarized as follows:

Ley and arable treatment crops (units N/acre)

	Grass/clover leys	Lucerne leys	Sugar beet, Mangolds	Spring cereal
Low nitrogen	20	nil	50	20
High nitrogen	80	30	100	40

Mangolds are grown instead of sugar beet at Rosemaund and Trawscoed. The spring cereal is barley at all centres except Boxworth where spring wheat is grown.

Testing crops (units N/acre)

	Potatoes	Wheat	Barley
Low nitrogen	50	30	20
High nitrogen	100	60	40

The chief divergencies from these rates are that, at the two West Country centres (Rosemaund and Trawscoed), the rates for the cereals are reduced and at the lower level no nitrogen is given.

Phosphate, potash and lime are applied at rates generous enough to minimize the risk of any deficiency in any crop.

Results

The information so far obtained is considered under three heads, namely, 1 output from the treatment leys, 2 yields of the three test crops, and 3 soil organic matter status.

Output from the leys

Production from the cut leys was determined by taking successive cuts during the season when the herbage reached the stage of growth for normal commercial silage making. The productivity of the grazed leys was measured by taking pre-grazing cuts, with a rotoscythe, of the herbage offered to stock, and then grazing the sward with cattle or sheep (generally sheep) as nearly as possible to the level of the cut.

At the two West Country centres, Rosemaund and Trawscoed and also at Bridget's, the yearly production of dry matter from the grazed ley was 7–12 per cent less than from a similar ley receiving the same rates of fertilizer and cut for conservation. At Boxworth and Gleadthorpe, where the average annual rainfall is around 24 in., the output of the ley cut for conservation was much greater than if managed for grazing: on the clay at Boxworth, 45 per cent more dry matter per year was obtained by conserving the grass rather than grazing it, and on the sand at Gleadthorpe 25 per cent more. Under a system of cutting for conservation, the lucerne ley was more productive than the grass/clover ley at all farms except Trawscoed. Raising the rate of nitrogen from 20 to 80 units per acre per annum increased the yields of dry matter from the conserved ley by 18 per cent and from the grazed ley by 20 per cent on average. As might be expected the responses to extra nitrogen were less at the high rainfall centres. The lucerne leys responded only slightly to dressings of nitrogen.

Yields of the test crops

Potatoes. This is the first test crop taken after the break up of the treatment leys or after the final crop of the arable sequence. During the first six to eight years that the experiment has been in progress, the most remarkable feature of the potato yields has been the absence of any appreciable effect on output from the three years down to grass. On average, the potatoes after the grazed ley yielded only about $\frac{1}{2}$ ton per acre or 5 per cent more, and those following the cut ley were no better than after the arable sequence. Potatoes after the cut ley and arable sequence benefited more from the heavier dressings of nitrogen than the grazed ley, and therefore the differences at the high rate of nitrogen were even smaller. Dung was also more effective for potatoes following the cut ley and arable

sequence than after the grazed ley. The potatoes, whether dunged or not, received generous dressings of inorganic phosphate and potash, and it is therefore reasonable to deduce that the greater part of the response to dung was due to the nitrogen which it contained. The results therefore suggest that, in the presence of adequate amounts of nitrogen, potato yields are very little affected by the nature of the previous three years cropping. This is in line with recent findings reported from the Grassland Research Institute, which indicate that the effect of a ley on succeeding crops can largely be measured in terms of the extra nitrogen derived from the ley residues, and that any changes in soil structure that occur after three years in grass are too small to influence crop yield.

Since both grazed and cut leys received equal quantities of nitrogen during their life, it would be expected that more nitrogen would remain for the next crop under a system of grazing management than where nitrogen was removed in the cut herbage, and this would explain the superior yields recorded after the grazed ley.

These general conclusions are based on the average yields from all six Farms. The results at the individual centres were fairly consistent, but at Rosemaund and Bridget's the improvement in yield after the grazed ley, as compared with the arable rotation, was more clear cut than at the other Farms and was not lessened by the use of extra nitrogen.

The silty heavy loam at Rosemaund appears to be one that may deteriorate in structure under a system of continuous arable cropping, and it is surprising that the potatoes following the cut and lucerne leys were no better than after the arable sequence.

Wheat. In the second year after ploughing up the leys the beneficial effect of three years in grass was more clearly in evidence. Although the yields of the second test crop, wheat, in the arable rotation were on average only about 6 per cent lower than after the grazed ley, the difference was more marked at three of the Farms, namely, at Gleadthorpe on sand land and at Bridget's and High Mowthorpe on chalky loams. At Gleadthorpe, wheat yields in the arable rotation were 10 per cent less than those after the grazed ley, the corresponding figure for Bridget's and High Mowthorpe being 9 per cent and 8 per cent, respectively. These better than average results after the ley contrasted with those at Boxworth, where heavy yields of wheat were obtained which were as good in the arable rotation as after the grazed ley.

There was a slight and not very consistent indication that better responses to nitrogen were obtained in the wheat in the arable and cut ley rotations than in the grazed ley rotation.

Barley. This is the third testing crop following the treatment sequences and the downward trend of production in the arable rotation, which was apparent in the wheat crop, is rather more evident in the succeeding barley. On average, barley in the arable rotation has yielded about 10 per cent lower than in the grazed or cut ley rotations. At High Mowthorpe, however, the margin between them is as much as 20 per cent, and some of this difference is accounted for by the greater amount of weed growth in the barley of the arable rotation. These weeds are difficult to control in an experiment of this nature, because the proximity of undersown plots limits the choice of herbicide which can safely be used under the windy conditions at this Farm.

Changes in organic matter

Soil samples are taken every three years, i.e., at the end of the treatment sequence before the leys are ploughed up and after harvesting the undersown barley, which is the final test crop before the next treatment sequence. These samples are analysed for their organic matter content, hereafter referred to as OM. The indications so far are that only small changes in the amount of OM present in the soil have been recorded during the first ten years of the experiment, certainly not enough to show any differences in this respect between the different rotations. The effect of the ley might be expected to show most clearly at Gleadthorpe where the OM status is inherently low. At this centre the average level in the top 12 in. of soil at the start of the experiment before any treatment sequence started was 1·55 per cent. After the three-year leys it rose to 1·69 per cent, compared with 1·60 per cent after the arable sequence. The slight advantage shown after the ley was lost at the end of the next testing sequence, potatoes, wheat and barley: the OM at this stage was 1·68 per cent in the ley rotation and 1·66 per cent in the arable rotation. All these figures represent averages of three series of plots started in successive years. At Boxworth, where the OM was around 3·1 per cent in the top 12 in. at the start of the experiment, virtually no change occurred after six years either in the three-year ley or arable rotations. Generally speaking this was also true for the other Farms. The results at Rosemaund have a special interest, since this is the farm where the soil is particularly "difficult" and problems of structure are often encountered. Here the original level of OM was about 3 per cent, and six or nine years of the experiment reduced it by about 0·4 per cent for all the three-year leys and the arable rotation. In addition, the stability of the crumb structure was assessed by sieving the soil under standard conditions. It was found that the proportion of larger particles (as held by a 16-mesh sieve) was 20 per cent less (after six or nine years of the experiment) where an all-arable rotation had been taken, as compared with one including the three-year ley. This seems a clear cut indication that, on a soil where structural problems may develop, continuous arable cultivation can bring about measurable changes in structure quite quickly. As was pointed out (p. 4), these changes were not accompanied by any appreciable effect on crop yield, but the very fact that they have taken place in the early years of the experiment suggests that, if unbroken arable cropping continues for much longer at this Farm, yields may suffer more drastically. It is emphasized that the general picture presented here relates to the opening years of a long-term experiment and it would be unwise to conclude that, because only small changes in organic matter status or other soil characteristics have so far occurred, they will not become more clearly defined as time goes on.

EQUIPMENT AND METHODS FOR SWATH TREATMENT OF HAY

Claude Culpin

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Experiments at the Experimental Husbandry Farms on the swath treatment of hay had established the following basic facts by the end of the 1959 season:

1. high quality and low losses require the time during which the crop lies in the swath or windrow to be as short as possible;
2. for quick haymaking, the crop must be cut when there is a reasonable prospect of fine weather;
3. early swath treatment is a fundamental need;
4. if unmodified flail forage harvesters designed for silage making are used to cut the crop, the rate of drying may be rapid, but loss of crop can sometimes be serious.

The work from 1960 onwards dealt with the effects of using modern tedders, forage harvesters with specially designed hay attachments, crimpers and roller crushers, in conjunction with the normal side-raking and baling equipment.

No attempt is made in this article to present a detailed account of the many experiments which have been carried out by the Bridget's, Boxworth, Drayton,[1] Gleadthorpe and Great House Experimental Husbandry Farms. Crops cut for hay, the weather during making, individual makes of machine and methods of use are very varied, and it is inadvisable to attempt to average the results obtained from farm to farm or even from different experiments on the same farm. Nevertheless, it is possible to draw from the wealth of information now available some positive conclusions of great practical importance to farmers.

Eighteen separate experiments have been carried out. Four different makes of tedder, five of forage harvester and two each of crimper and roller crusher have been included as the opportunity arose. In the main, the swards have been general purpose ryegrass leys and over the three years 1960-62 all the kinds of "haymaking" weather have been encountered.

A careful study of the results shows that similar experiments carried out on the different Farms have not invariably led to exactly the same conclusions. This is partly explained by differences in the machines. For example, flail forage harvesters sold by different manufacturers are not equally suitable for haymaking. Different methods of operating the machines and different crops can also have marked effects on machine performances.

This type of experimental work is primarily of short-term value. It has already, through farm walks, lectures and advisory work, made thousands of farmers aware of the advantages of and snags in some of the newer methods. It has also already caused manufacturers to modify their machines to make them more suitable for their intended purposes.

The following conclusions should therefore be read with the understanding that machines can and will be modified, and that changes in equipment and further experiments may necessitate a revised judgment at some time in the future.

Use of Flail Forage Harvesters for Cutting

Forage harvesters used for direct cutting have been compared with conventional reciprocating knife mowers followed by the back-action tedders at Boxworth, Bridget's, Gleadthorpe and Great House in eight trials. These have included early and late cutting dates.

Provided that the flail forage harvester is suitably designed and intelligently operated, it can be used successfully for cutting most types of hay crops, but there are some unsolved problems, which are mentioned below. Its use can

[1] Crop conditioning experiments. Part I. Drying rates and yields. G. Shepperson, J. K. Grundey and R. Wickens. Experimental Husbandry 8 (1962) 6584.

result in the crop being ready for baling 1–2 days sooner than if only a tedder is used for swath treatment, and appreciably sooner than if the crop is tedded by flail, or treated once with a crimper or roller crusher immediately after cutting. This can result in hay of high quality, when similar material cut by mower and only tedded is partially spoiled by rain. There are, however, certain drawbacks which should not be overlooked. These are:

1. there is a tendency for a longer stubble to be left by the flail. This can arise either from too high a setting, or from ragged cutting due to too low a rotor speed. It often results in the amount of crop cut being about 10 per cent less than is obtained by using a finger-bar mower;
2. because of its narrower width of cut, cutting by forage harvester is a rather slow operation, yet requires a powerful tractor;
3. very young, clovery crops and very stemmy grassy crops are unsuitable for harvesting by forage harvesters as at present designed;
4. most of the equipment available for subsequent operations (swath turners and side-rakes) is not at present well suited to working the closely spaced swaths.

If a flail forage harvester is used for cutting the crop, it is essential to avoid excessive chaffing by working at a high forward speed (3–4 m.p.h.) and moderate or low rotor speed, and in subsequent swath treatments to avoid excessive spreading of the swath. If, however, a high forward speed and low rotor speed would lead to a serious loss of crop due to a long stubble, rotor speed should be increased until the stubble is satisfactory. Results at Gleadthorpe help to underline the disadvantages of using a forage harvester for cutting hay where crop conditions are unfavourable. In a light, stemmy crop in 1962, a properly modified machine was used at the best possible settings of rotor speed and forward speed; yet the result was a loss of almost 50 per cent of the crop, due mainly to failure to pick up the short pieces. On the other hand, results at Boxworth showed that it is possible to make the crop with very little loss after this method of cutting provided a fairly long stubble is accepted.

As a general rule, the most suitable machine to follow this method of cutting by flail is a finger-wheel swath-turner/side rake. The swaths must be gently turned over, so that any small pieces remain with the longer ones. It is generally a mistake to use a tedder or to use the forage harvester again after cutting by forage harvester. If such machines are used, the swath should be kept narrow and well set up. There are practical difficulties in matching finger-wheel machines to 40 in.-cut harvesters, and there is considerable advantage in a swath at least 48 in. wide, provided the tractor has sufficient power. There is an obvious practical advantage in a machine which requires only the movement of a baffle plate to convert it from loading silage to swathing hay.

Use of Flail Forage Harvesters for Tedding

Treatments comprising the single or multiple use of the various flail forage harvesters for tedding a crop mown with a normal cutter bar have been a feature of most trials.

Suitable forage harvesters can be effectively used for an early tedding operation. In the same way as when the forage harvester is used for cutting, a high forward speed and moderate or low rotor speed should be used. Repeated tedding by flail is generally inadvisable, though it may be practicable with machines which have been specially modified by fitting hay tines. As a general rule not

more than two teddings by flail should be carried out, and these should be in the early stages of drying. Tedding by flail does not produce such rapid drying as cutting by flail, and is slightly less effective than a crimping; but it can give a worthwhile improvement in drying rate over the use of a tedder, and the loss of yield sometimes associated with cutting by flail can be avoided.

If the forage harvester is to have an assured future as a tedder, it seems essential that it should be equipped with a two-way hood for easy conversion from loading to swath treatment, and desirable that it should be easily fitted with hay tines.

Crimpers and Roller Crushers

Most of the work on crimpers and roller crushers has been done at Bridget's and Drayton, although some roller crusher comparisons have been made at Great House. The crops used have generally been cut in June, but nevertheless a range of maturity has been experienced and this appears to have influenced the results.

The results of using crimpers and roller crushers have, on the whole, been very satisfactory. The improvement in drying rate is not quite as great as that achieved by cutting with a flail forage harvester but, compared with using a tedder only, generally a day can be saved, and the operation carried out without much loss of time or of crop yield. American machines designed for 7 ft swaths do not work well after a 5 ft mower. The way to use both crimpers and roller crushers is with a single tractor for mowing and swath treatment, the swath treatment machine running at the rear of the tractor and treating the swath cut on the previous round. This can be a practical method with either a side- or rear-mounted mower. There is still much to be learned about essentials of design of crimping or crushing devices. At Drayton, the crimper has almost invariably been very effective. A comprehensive series of experiments, carried out in conjunction with National Institute of Agricultural Engineering, showed that, two days after cutting, the moisture content on the crimped plots was generally from 5 to 15 per cent lower than that on the control (tedder only) plots. Similar good results have been obtained with both the crimper and roller crusher used at Bridget's, and with the roller crusher used at Great House. At Boxworth, however, the first year's results, using another make of crimper, were disappointing. There are differences of degree in the value of the repeated use of crimpers between Drayton and Bridget's. At Drayton, the general conclusion is that there are normally insufficient advantages in repeated crimping to justify more than one treatment, whereas at Bridget's, where crops were generally cut before anthesis, one treatment has sometimes been disappointing. Discrepancies may be due partly to differences in severity of the treatment and partly to the stage of maturity of the crop. Further experiments are needed to decide whether a crimper should replace a tedder completely, or whether it has to be regarded as an additional machine.

ACKNOWLEDGEMENT

The writer is indebted to the Directors and staff of the Boxworth, Bridget's, Drayton, Gleadthorpe and Great House Experimental Husbandry Farms for providing the results of their experiments and for assistance in the compilation of this progress report.

WILTING FOR SILAGE

S. Culpin

Director, Drayton Experimental Husbandry Farm

High quality grass silage can only be produced by cutting a young crop which contains a low proportion of dry matter. The reason for wilting before ensilage is to increase the percentage of dry matter and this may include some or all of the following advantages:

1. a reduction in the quantity of effluent liquid draining from the silo;
2. an improvement in the conditions for fermentation and less necessity for additives;
3. because cattle and sheep will consume larger quantities of nutrients when fed high dry matter silage; they are potentially more productive than with low dry matter silage.

On the other hand, there may be disadvantages in increasing dry matter by wilting. For example:

1. the cost of making wilted silage may be higher than that of unwilted;
2. wilting may be an ineffective method of increasing dry matter in unfavourable weather;
3. wilting may lead to crop losses in the field;
4. There may be difficulty in controlling temperature in wilted silage and consequently in-silo losses may be increased.

Experimental Methods

In the period from 1957 to 1961, studies have been made of silage making losses at the Great House (Lancashire), Gleadthorpe (Nottinghamshire) and Drayton (Warwickshire) Experimental Husbandry Farms. In all cases, a comparison has been made between ensiling freshly cut grass crops and crops which had been allowed to wilt in the field before collection. The methods were to collect unwilted silage by direct cutting with a flail harvester and wilted silage by cutting with a conventional mower and picking up later with a flail harvester. The loads of grass were all weighed and sampled before ensiling and then, in the following winter, all the silage was weighed and sampled before feeding. Temperatures were recorded at all Farms by burying thermocouples in the herbage and the volume of effluent liquid was measured at Great House and Drayton.

The Silos

Great House. Box type under a barn: 22 × 22 × 10 ft high. Settled depth 8 ft. Covered with sleepers over whole area.
Gleadthorpe. Walled surface silo: 36 × 14 × 5 ft high. Settled depth 5 ft. Covered with temporary corrugated iron roof in 1957, ground limestone and temporary roof 1958. Permanent barn roof erected 1959 and ground limestone on polythene sheet in 1959, 1960, 1961.
Drayton. Concrete walled silo under Dutch barn: 40 × 14 × 6 ft with ramp at one end. Settled depth 5 ft. Covered with polythene sheet and sleepers or straw bales.

The silage-making conditions were good by general farming standards but the silos were rather small.

Farming Conditions and Field Work

Great House is a Pennine farm. The average rainfall is about 60 in. annually and silage is made for a dairy herd. At Gleadthorpe and Drayton, silage is made for growing and fattening cattle and about 24 in. of rain falls annually in lowland conditions.

Some farmers object to wilting grass for silage making due to mechanical difficulties, but at the three Farms described no insurmountable difficulty was encountered. Since the swath of grass was to be picked up by a 40-in. flail harvester, suitable boards were fitted to a 5 ft mower so that the swath was contracted to a width less than 40 in. This precaution is essential to prevent wrapping round the flail shaft and to ensure a clean pick up. On a few occasions a machine with a pick-up reel was used and the same principle applied.

On the two low-rainfall Farms, the weather practically always allowed wilting to proceed satisfactorily, but at Great House there were occasions when the wilted grass was just as wet as fresh grass collected a day earlier. In spite of this, the average wilting of whole silos showed a satisfactory reduction of moisture content.

It is natural to expect that direct cutting will be more economical of labour than two-stage harvesting, but records collected at Drayton in 1959 showed that this is not necessarily so: on that occasion wilted herbage was collected with less labour than fresh herbage, the reasons being that: *a* a 5ft mower could travel faster, as well as take a 50 per cent wider cut, than a 40-in. flail harvester and *b* the flail could travel faster whilst picking up a wilted 5 ft swath than whilst direct cutting a 40-in. swath. On the other hand, wilted herbage was less lacerated due to the faster speed at which it was collected. The average gross weight of a load was decreased by wilting, but the net weight of dry matter stayed the same whether or not the grass had been wilted. In other words, the loss of water did not cause any shrinkage of volume and thus did not allow more dry matter to be carried per load.

Field Losses

If cut grass lies in a swath, it may lose moisture at a rate varying from 1 per cent per hour in good weather to none at all in drizzle or in good weather during the hours of darkness. Within the 24-hour period normally allowed for wilting, loss of crop due to respiration is unlikely to exceed 1 per cent. On the other hand, wilting entails picking up a previously cut swath and this is usually the cause of rather larger losses. In practice, farmers are concerned with the total wastage from both causes and in seven separate experiments involving weighing about 800 tons of silage the results were as shown in Table 1, p. 11.

The table shows an average field loss of about 5 per cent of the crop dry matter at both centres. Clearly this 5 per cent "loss" is not all wasted if stock are turned into fields to clean them up immediately after collecting wilted silage. Due to the better climate wilting has been rather more effective at Drayton than at Great House.

TABLE I

	Wilting time (hours)	Field losses as percentage of total crop dry matter	Reduction in moisture content (per cent units)
Great House	24	6·5	2·3
	24	4·2	12·3
	19–24	4·5	0·7
Drayton	48	8·3	5·3
	24	2·7	9·0
	24	3·3	13·7
	24	8·2	12·5

Effluent Liquid

Liquid draining from the silos has varied in dry matter content from time to time, but has averaged about 4–5 per cent or 1 lb dry matter for every 2 gal of effluent. Thus, although the volume may amount to 20 gal per ton of grass at 20 per cent moisture content and its disposal may be a problem, the actual loss of food value is relatively small.

Considerable variation was found in the volume of effluent but two principles became clear: *a* at 27–30 per cent dry matter the effluent problem disappears and *b* at about 20 per cent dry matter there is a serious problem: at that level a decrease of one unit in dry matter percentage leads to a proportionately greater increase in volume of effluent than it does at, say, 25 per cent dry matter.

Silo Temperatures

One of the objections to ensiling wilted herbage is that high dry matter silage may increase in temperature to an undesirable degree unless special care is taken with consolidation. At all three Farms very high figures were recorded in the upper layers from time to time whether the crop had been wilted or not. Even in the middle of the silage where the conditions represented a truer picture of the whole bulk it was clear that wilted silage is liable to rise to higher temperatures than unwilted, but, by taking suitable precautions, it is possible to keep the temperature of high dry matter silage down to a satifactory level. The results obtained at Great House illustrate this. In 1959 the method was to introduce about 9–10 tons in the first two days and allow this to warm up before carrying on. The result was too high a temperature, 137°F (58°C), at a wilted dry matter of 25·7 per cent and a satisfactory temperature, 87°F (30°C), at 18 per cent dry matter. But in 1960 and 1961 all the material in both silos was blown in as quickly as possible and sealed down immediately. The result was that very little heating took place even in wilted silage at 33·5 per cent dry matter. At Drayton, too, since 1959 the silos have been filled quickly and temperatures have been controlled more effectively.

Inedible Waste Material and Fermentation Losses

The methods of dealing with the silage when it was removed from the silo differed at the three centres.

At Great House everything in the silo whether edible or not was weighed in bulk and after that the "waste" was thrown out on pasture and picked up by dry or growing stock. Only first-class material was offered to the dairy herd and a good deal of edible material went with the waste. Thus there was a determination of the fermentation loss but not of the truly inedible material.

At Gleadthorpe the waste material was discarded and only edible material weighed. Thus the estimate arrived at was the total loss including loss due to surface waste.

At Drayton the decayed surface was peeled off from the top and shoulders of the silage each time there was a new cut down the silo. This was weighed separately from the edible silage.

At all three centres, the estimates of losses were obtained by subtracting what was weighed and analysed in winter from that weighed and analysed at silage-making time. The results from the three centres are presented separately in Tables 2, 3 and 4, as the percentage of in-going herbage on a dry matter basis.

TABLE 2

Great House. In-silo losses (but not including waste material)

	Unwilted	Wilted
1959	31·0	26·4
1960	18·1	8·3
1961	24·3	23·5
Mean	24·5	19·4

TABLE 3

Gleadthorpe. Total in-silo losses (including waste material)

	Unwilted	Wilted
1957	33·8	29·0
1958	22·7	29·3
1959	26·2	16·3
1961	32·1	29·1
Mean	28·7	25·9

From Table 4 (p. 13), the average figures for waste are 4·8 and 7·0 per cent for unwilted and wilted silages, respectively. If adjustments on this basis are made to Table 2, then there is a good measure of agreement between total loss figures for all Farms, the inference being that wilting has reduced the in-silo losses from:

29·3 to 26·4 per cent at Great House
28·7 to 25·9 per cent at Gleadthorpe
26·0 to 24·0 per cent at Drayton

TABLE 4

Drayton. In-silo losses (fermentation, effluent and waste shown separately)

	Unwilted				Wilted			
	Effluent	Waste	Fermentation	Total	Effluent	Waste	Fermentation	Total
1957	—	4·8	21·9	26·7	—	7·9	20·0	27·9
	0·3	5·0	20·4	25·7	—	2·9	20·9	23·8
1958	1·2	4·8	22·7	28·7	0·4	5·8	12·7	18·9
	0·6	3·5	17·1	21·2	0·4	4·4	9·6	14·0
1959	1·3	5·3	18·4	25·0	—	8·2	16·3	24·5
	1·2	6·6	22·6	30·4	—	12·0	19·5	31·5
1960	0·1	3·8	20·2	24·1	—	7·9	19·4	27·3
Mean	0·7	4·8	20·5	26·0	0·1	7·0	16·9	24·0

However, the considerable variation between different years indicates the unpredictability of silage making and there were five out of fifteen occasions in which the wilted were greater than the unwilted losses.

Allowing for the fact that percentage losses from waste would be reduced in large silos, the farming picture from cutting to feeding is that from a given crop; wilting produced about the same quantity of dry matter as ensiling it fresh.

Silage Quality

Analytical figures did not indicate any real differences in the silage quality according to its dry matter content, neither was there any difference in digestibility of the samples fed to sheep, except at Great House on two occasions when wilting increased digestibility. But from the Research Institutes both in this country and the U.S.A., there is clear evidence that high dry matter and high appetite for silage go together. It is equally clear that high performance goes with high intake and thus the case for high dry matter silage as a feedingstuff is well established.

Summary and Conclusions

In trials at three Experimental Husbandry Farms it was found that:

1. collection of wilted silage involved a field loss (mainly mechanical) of about 5 per cent of the crop but not all this was wasted;
2. collecting wilted silage did not necessarily need more labour than unwilted silage;
3. the silage effluent problem was eliminated by wilting to just under 30 per cent dry matter;
4. temperature control became more difficult above 30 per cent dry matter;
5. in-silo losses were reduced by wilting.

It is concluded that the main benefits of wilted silage are avoidance of effluent and the increase in voluntary intake by animals. These benefits are considered to more than repay the trouble taken.

A PERFORMANCE TEST OF BEEF BULLS

A. L. Francis

Rosemaund Experimental Husbandry Farm

The wide variation in growth rate among apparently similar animals has long been known, but increasing skill in farming and management has drawn attention to that part of this variation which is genetic in origin. A performance test which records the growth of contemporary animals reared together under standard conditions will indicate the extent of genetic variation, but the extent to which a parental characteristic is passed on to offspring is only measurable by an expensive and time-consuming progeny test. If, in such a test, a characteristic proves to be inherited to a satisfactory degree, then it would be possible to select breeding stock by means of the less expensive direct performance test.

A combined performance and progeny test of pedigree Hereford bulls began at Rosemaund Experimental Husbandry Farm in the autumn of 1957 when ten calves began their test. In each of the three following years further intakes of calves have been tested. The second part, involving the testing of twelve male crossbred progeny from each bull, has been in progress since 1959. In both cases the characteristics measured have included liveweight gain, food use, changes in a number of body measurements and visual appraisal.

The performance test on the bulls is now complete. At the end of the progeny test in 1964, it will be possible to estimate how far the performance test foretold the results of the progeny test, and thereby determine its usefulness as a means of selecting breeding stock for beef production.

Methods Used

Management and feeding

A panel of Livestock Officers selected autumn-born bull calves when two or three weeks old, to represent the different types of bull used for crossing with dairy cows. The calves were reared at Rosemaund on a system that provided uniform conditions, but allowed each one to eat and grow as fast as possible, subject only to its remaining in good health. In the first year, the calves began their test at 80 days of age, but in later years it was possible to begin at 34 days of age; all were weaned at 181 days and completed their test at 400 days of age. They were housed in individual pens. The amount of straw bedding was limited to avoid its being eaten, but covered a sufficient area to give the animal a comfortable bed. Exercise, without the chance to graze, was provided twice a day, the calves were groomed daily and washed when necessary. There was a veterinary inspection at regular intervals; feet were trimmed and horns trained if required.

A standard method of feeding is very important in this type of performance test. The young calves were suckled twice a day on autumn-calved Dairy Shorthorn foster-mothers, and weighed before and after suckling at both feeds on two days each week. From this estimate of consumption, it was possible to arrange that each calf had the opportunity to consume a similar amount of milk by the time it was weaned. The rest of the diet was of the varied composition successfully used to rear bulls in this country. Good hay and water were always

available. After weaning, standard amounts of succulents were fed by day and a mash was fed at night. The concentrate was a home mix containing 60 per cent starch equivalent and 12 per cent protein equivalent, the constituents being altered slightly at weaning and again when the calf was nine months old; these were fed three times a day. Initially, the hope was to feed the concentrates without any restriction, but experience during the first year showed that this led to digestive upset. For the last three years the animals were fed to "the edge of appetite," when the stockman would increase the amount of feed at frequent intervals. If the animal took this extra it was continued, but at any sign of trouble it would revert to the previous amount.

Records taken

Full records were kept of all food fed and refused. All changes of diet were made on the same day of age for each animal.

All animals were weighed first thing in the morning once a week, and three mornings in succession every four weeks at the start of the test, at weaning and at the end of the test. The record of growth included a description of the changes in body proportion and nine body measurements which were taken at the start, at weaning and at the end of the test.

All the animals were photographed under similar conditions at the same times.

The health of the animals was generally good. Forty animals completed the test, two died from unidentified causes when more than halfway through the test, while two other developed bone defects. The bulls were presented for licensing in the normal manner.

Summarized Results of the Test

Live weight

The range and mean liveweight gain of each intake is shown in Table 1. (For a more detailed discussion of this and other aspects of the test see Experimental Husbandry 9 (1963), pp. 53-65.

The variation between years is not significant, but does emphasize that a fair comparison between individual animals can only be made when they are tested at the same time and in the same place.

By arrangement with the Hereford Herd Book Society, it was possible to compare the animals on test with those presented for sale in October and December 1959 and October 1960. Most of the bulls in comparable classes were weighed and on weight for age there was little difference in range or mean. This suggests that conclusions from this test may well apply to the majority of the breed.

Tests abroad have standards for "premium" animals that vary from 2·3 to 2·61 lb/day. The Rosemaund experiment suggests that a Hereford bull, reared in the manner of these tests, should do 2·50 lb/day and that a premium standard might be 2·75 lb/day.

TABLE I

Yearly range and mean for live weight and daily gain

	Live weight (lb)			Daily weight gain (lb/day)		
	Start	Weaning	Finish	Pre-weaning	Post-weaning	Overall
1957						
Highest	278	699	1254	3·80	2·87	3·08
Lowest	181	466	1021	2·50	2·25	2·53
MEAN	247	572	1130	3·21	2·56	2·76
1958						
Highest	182	620	1160	2·98	2·71	2·71
Lowest	113	481	983	2·40	2·18	2·33
MEAN	151	544	1066	2·67	2·39	2·50
1959						
Highest	180	626	1207	3·21	2·78	2·85
Lowest	121	499	955	2·50	2·09	2·28
MEAN	144	551	1079	2·77	2·42	2·55
1960						
Highest	188	601	1216	3·18	2·89	3·01
Lowest	115	505	971	2·43	2·12	2·27
MEAN	147	541	1100	2·68	2·55	2·60

Food use

The food conversion ratio as expressed by

$$\frac{\text{Starch equivalent consumed}}{\text{Total weight gain}}$$

showed a difference of 10·5 per cent between the most and least efficient bulls in any one year. It was possible to show a close relationship between efficiency of food conversion and rate of liveweight gain, insofar as the more efficient animals were also the ones with the higher rates of liveweight gain. This has the most difficult part of a performance test, both in the daily record and the validity of the food samples. Performance testing would therefore be that much easier if this relationship were acceptable from the start.

Body measurements

Apart from the photographic record, the body measurements completed the objective assessments made in this trial.

All body measurements increased more in the five months up to weaning than in the seven months afterwards. There is a definite relationship between body weight and chest girth and this is the basis of the weighband; body weight bears a similar but less definite relationship to other measurements. However, the relationships become less precise as the animal grows and measurements cannot

be recommended as a substitute for weighings in performance testing. Despite the relation between food use and daily rate of gain, there was no significant relation between any body measurement and the use of food.

Visual appraisal

Subjective assessment took the form of a simple visual appraisal. Members of the Hereford Herd Book Society placed the animals of each intake in order of visual merit at the end of their test. This conformed to the system normally used in the show ring. There was very little relationship between this index for visual merit and liveweight gain.

An Index for Selection

This test is ultimately concerned with the heritability of liveweight gain and other characters among crossbred beef animals. The progeny test part of the experiment is still in progress and will not be finished before the spring of 1964, when more conclusive comment can be made. Nevertheless the results of the performance test can be used to demonstrate a possible method for the selection of breeding bulls. The performance of animals can only be compared when the breed, sex, time and place of test is the same. If the performance for any given factor of each animal is related to the average of all, it will give an index of performance for that particular factor. In this test an index can be made for liveweight gain, efficiency of food use, visual merit and for each of the body measurements. These can be combined into a single index in various ways when the separate factors can be weighted as desired, but it is probably more important to specify that a selected animal shall be at least average for all factors tested. Some of the results from the first year demonstrate this, using three factors.

TABLE 2

Performance indices of some bulls tested 1957–58

Index Bull code	Live weight Gain/day (LL)	Food use (IF)	Visual merit (IV)	Overall* (IO)
A_1	92·2	96·1	140·4	112·3
B_1	96·8	94·3	92·6	94·6
F_1	102·5	104·7	89·6	97·8
I_1	102·1	99·7	119·5	108·6
J_1	110·3	104·0	119·5	112·7

$$*IO = \frac{2IL + IF + 2IV}{5}$$

B_1 is below average for all three factors, A_1 and F_1 show how one component (IV in this case) may influence the overall index. I_1 is a borderline case for one component index (IF) while J_1 is above average for all three factors. Out of forty bulls tested over four years, eighteen had an overall index above average, but only six had all component indices above average, and three of these now stand at insemination centres.

The full value of this performance test cannot be assessed until the progeny test has also been completed.

SOIL FERTILITY EXPERIMENTS WITH VEGETABLES

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There is a lack of information on the nutritional requirements of vegetable crops. This is partly historical because of the situation of many market gardens near to centres of population, so that fertility was built up by return loads of suitable manure, but in addition the high value of vegetable crops has led to heavier than necessary fertilizer dressings being applied as insurance against poor yields. Changes are, however, taking place. The growth of towns has led to old market gardens being taken over for building, and crops have now often to be grown on new sites of lower fertility. The increased use of irrigation and of fertilizers, especially for vegetables grown as farm crops, has meant that they can be grown confidently on these sites with less dependence on stable or farmyard manure. Knowledge of the basic nutrient needs of these crops is, however, all the more necessary.

In the years prior to 1946 work on the effects of farmyard manure and various fertilizer treatments was carried out at Long Ashton Research Station on a wide range of vegetable crops, including cauliflower, spring cabbage, savoys, summer cabbage, red beet and carrots. The main requirement was for nitrogen, even in the presence of bulky organic manures, although potassium was reported to be important for carrots.

Since the establishment of the National Vegetable Research Station, further information has become available, mainly on the effects of different forms of nitrogenous fertilizer and of farmyard manure which appeared to reduce the response to nitrogen.

Results obtained in experiments carried out at a research station suffer from the disadvantage that they may only apply to a particular soil type under the climatic and other conditions prevailing. More confidence can be felt in the general application of the results of experiments if the same trends can be shown to occur on a number of widely separated sites typical of the main growing areas. This is achieved, in some measure, in work carried out by the Experimental Horticulture Stations and reviewed in this article.

Ideally, a further stage is to confirm the results by trials on growers holdings under a still wider variety of soils and conditions, but in practice this is extremely difficult with manurial experiments. The strip cropping on many market gardens makes it difficult to obtain uniform sites, horticultural crops, often harvested over a period, present difficulties in recording and the smaller responses to fertilizers found on the fertile soils of horticultural holdings are difficult to measure.

In practice, it is desirable to find out on the more fertile soils when and to what extent fertilizer dressings can be reduced, especially in view of the evidence that under some conditions yields may be reduced by excessive or unbalanced manuring.

Nutrition Reference Plots

These are long-term plots which measure the cumulative effect of nitrogen, phosphate, potash and farmyard manure, alone and in combination with each other when applied annually to a rotation of crops. There are usually ten plots in each block with the following treatments—O, N, P, K, NP, NK, PK, NPK, D, DNPK—where O=no fertilizer; N=nitrogen; P=phosphate; K=potash; D=dung; at some centres extra plots have been added for magnesium and trace element treatments.

The plots are normally cropped in rotation, the number of blocks corresponding to the number of courses, so that in any year each crop is represented. The actual manurial treatments are varied with the crop, but the same plots always get the same plant nutrients.

Experiments of this type were laid down at four Experimental Horticulture Stations soon after they were set up in order to gain some basic information on the manuring of the particular soils represented and, except at Stockbridge House, are still being continued, although in some cases in a modified form.

These plots are of little value in determining the optimum level of manuring for a particular crop, but they do enable us to pick out which crops are more or less responsive to a particular nutrient, as well as providing information on the level of soil analysis at which deficiencies occur and on the symptoms of nutrient shortage in the plant.

The soils of the three Horticultural Stations, Efford, Luddington and Rosewarne, where reference plots are still being carried on, vary in type and chemical composition. At Efford, where the soil is a deep, brick-earth deficient in phosphate and potash, the only horticultural crops grown on the plots have been autumn cauliflower and broad beans. At Luddington, on a sandy loam derived from coarse, sandy drift material well supplied with phosphate but low in potash, lettuce, summer and autumn cauliflower, beetroot and runner beans have been grown. The Rosewarne plots were in twelve blocks and a wide range of crops has been taken on the stony loam derived from clay over Mylor slates and very deficient in phosphate and potash. The vegetable crops have been beetroot, carrots, lettuce, peas, early potatoes, runner beans, broad beans, spring cabbage and winter cauliflower (broccoli).

The results obtained may be summarized as follows:

Brassicas

Summer and autumn cauliflower at Efford and Luddington were very responsive to nitrogen, the requirements of the early summer varieties, All-the-Year-Round, Snowball and Cambridge No. 7 being apparently much greater than that of the autumn variety Majestic. The autumn crop responded to phosphate at Efford on a deficient soil but not at Luddington, while there was no effect on yields from potash at either centre.

Winter cauliflower gave variable results at Rosewarne but in 1960–61 nitrogen, phosphate and potash all gave big yield increases.

Spring cabbage gave large responses on the deficient Rosewarne soil to phosphate and nitrogen while there was also a smaller effect from potash.

All brassica crops gave increased yields with farmyard manure, but the effects were probably largely due to its supply of nutrients.

Legumes

Broad beans were grown at Efford and Rosewarne. At Efford there was little or no response to fertilizers, but at Rosewarne they behaved unlike other crops in that the effect of potash was large and that of phosphate small. At both centres farmyard manure gave high yields which could not be achieved with fertilizers at least at the levels used.

At Luddington runner beans responded well to nitrogen and potash, but not to phosphate. At Rosewarne, where they were grown under exposed conditions, there was also a response to potash and a smaller one to phosphate.

Legumes appear to be able to obtain phosphate even from deficient soils, but to need potash fertilizer for full development.

Lettuce

At Luddington, there were small responses to nitrogen and phosphate in a transplanted crop. On a sown crop at Rosewarne, phosphate had a very large effect on numbers maturing, while there was also a small response to potash.

Beetroot

Where grown either for bunching or for harvesting at maturity there was a big response at Luddington to nitrogen, other effects being small. There was some indication that phosphate was necessary for the early bunched crop and potash for that grown through to the autumn. At Rosewarne, beetroot responded to nitrogen, phosphate and potash.

Early potatoes

This crop was grown only at Rosewarne, where it showed a large response to phosphate and smaller effects from nitrogen and potash.

Conclusion

Most crops gave large increases in yield from phosphate on the very deficient Rosewarne soil. Legumes appeared to be the exception for which potash was more important on this site. At Luddington, all crops responded to nitrogen while potash also improved the yield of runner beans and beetroot. Nitrogen and phosphate responses were obtained with cauliflower at Efford. There was some evidence that for a few crops, especially broad beans, lettuce grown at Luddington and perhaps others, farmyard manure gave crop yields which could not be obtained from fertilizers, possibly due to improvements in soil structure.

Residual Phosphate Experiments

These were laid down at Efford and Stockbridge House on similar lines to those carried out on Experimental Husbandry Farms (see also p. 31). The aim of the experiments was to compare four forms of phosphate fertilizer, superphosphate, di-calcium phosphate, basic slag and ground rock phosphate (Gafsa). When applied annually at rates of 20 and 40 units per acre P_2O_5 and at three-yearly intervals at 60 and 120 units per acre P_2O_5. The experiments on farm crops showed that superphosphate and di-calcium phosphate were superior to

the other fertilizers tested in the year of application. Residual effects were as would be expected, smaller in the second year after application than the first and were usually considerably less than in the year of application.

At Efford, a five-course rotation of potatoes, cauliflower, broad beans, two-years seeds was followed and at Stockbridge House, a four course of potatoes, carrots, cabbage and peas. On potatoes, the Stockbridge House results on an acid sand were similar to those reported for the Farms with superphosphate and di-calcium phosphate superior to basic slag and rock phosphate, but at Efford there was little or no difference between materials. Cabbage responded well to phosphate at Stockbridge House with rock phosphate and basic slag rather worse than the other materials, but the results with carrots and peas were rather irregular. At Efford, cauliflower and broad beans showed responses to phosphate in the year of application and small residual effects, especially in the first year after application.

Residual Potash Experiments

These have aims similar to those of the residual phosphate experiments and compare the effects of sulphate of potash when applied annually and at three yearly intervals. At both Efford and Stockbridge House, they adjoin and have been cropped similarly to the residual phosphate experiments.

Potatoes showed large responses to potash in the year of application with maximum crop obtained from about 80 units per acre K_2O at Efford and 120 units per acre (the maximum dressing) or more at Stockbridge House. Residual effects were obtained in the first and second years at Efford, but in the first year after application only at Stockbridge House. At Efford, cauliflower showed little response to potash which confirms the results of the reference plots described above. Broad beans benefited from up to about 100 units per acre K_2O with small residual effects also evident. At Stockbridge House, all crops showed responses in the first year, a reflection of the low potash status of the soil there, with optima around 60 units per acre K_2O for peas and 120 units per acre for carrots and cabbage. Peas and cabbage showed residual effects up to two years after application, but for carrots the effect in the second year was negligible.

Conclusion

These experiments were designed to give more information about the way in which phosphate and potash react when applied to the soil rather than to give practical information on manuring. At the low levels of fertility, relative to horticulture in general, found on these sites, annual dressings of phosphate and potash would be required for each crop, although there is evidently some scope for adjusting rates of application in relation to the type of crop being grown.

Manuring of Rhubarb and Winter Cauliflower

Rhubarb is an important crop in the West Riding of Yorkshire where it is often grown in rotation with winter cauliflower of local frost-resistant types. A manurial experiment on these crops grown in rotation was started in 1952. Even under conditions of low fertility then found at Stockbridge House, responses to phosphate and potash were very small, while the yield of forced

rhubarb per root was increased by up to 1·9 lb by dressings of 126 units of nitrogen per acre as sulphate of ammonia applied in each of the two years the roots were in the ground.

Further rhubarb crops grown on the same plots in 1957–59 and 1959–62 confirmed the previous results, large effects being obtained from nitrogen. With the 1957–59 crop there was also a small effect from the potash, presumably due to the exhaustion of the plots which have not received potash fertilizer since 1951.

Winter cauliflower at Stockbridge House suffers in severe winters from loss of plants which affected the experimental results on this crop in some years. The main response was to nitrogen which gave a big increase in marketable yield every year. The effects of phosphate and potash were small, although as shown by analysis there were soil deficiences of both nutrients.

Rhubarb, by virtue of its extensive root system, can evidently obtain phosphate and potash sufficient for growth even if the top soil is deficient. Winter cauliflower, if the plants are raised in fertile soil, can apparently also give good results without further additions of phosphate and potash on this soil. The results for this crop are, however, rather different from those obtained at Rosewarne, where big responses were obtained to nitrogen, phosphate and potash in recent years.

Top Dressing of Spring Cabbage

Work has recently been carried out at Rosewarne on the time and rate of nitrogen top dressing for spring cabbage. This crop, as indicated by the reference plots is very responsive to nitrogen and heavy rates of top dressing up to 300 units per acre have been tested. The heaviest yields were obtained from split dressings, half applied in January and half in February/March, 150 units per acre nitrogen being applied on each occasion.

At lower rates, better crops were obtained when the dressing was split than when all applied in January.

Several nitrogenous fertilizers were tested in these experiments and contrary to some other results sulphate of ammonia generally gave the best results.

Further work on spring cabbage, relating top dressing to times of sowing and planting out, is being carried out at Rosewarne, while similar experiments have also been started at Stockbridge House.

UNHEATED MOBILE GLASS: A REVIEW OF THE WORK OF THE STATIONS

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Mobile glasshouses cost about 12 to 33 per cent more than static houses of similar type and area. This is mainly because of the need to combine light construction for easy movement with rigidity and is of particular importance with wide span houses. Concrete dollies, drains and gullies to take surface water from a number of sites are also an additional charge, but as foundations and dwarf walls are not needed this is largely offset.

Several advantages have been ascribed to mobile over static houses but, if the high additional capital cost is to be justified, these must be considerable. Undoubtedly the main advantage of the mobile structure is the saving in labour with many cropping sequences. The preparation of the land for a crop can be done by quicker mechanical means on open ground than within the confines of the glasshouse. Direct planting or sowing in the open ground and moving the house over the growing crop requires much less labour than the boxing and potting or lifting and subsequent carrying of plants into the house. This advantage becomes more important as labour costs continue to rise. Of almost equal economic importance is the possibility of using the glass for productive purposes all the time, avoiding such periods as those used for clearing a crop, preparing the ground, or waiting to finish a harvest on a crop which goes on after the need for protection is past. The relative costs and values of the two systems, static and mobile, can only be obtained by comparison and this is being done at Luddington with unheated houses.

Much of the early work with mobiles on Experimental Horticulture Stations was on the study of cropping sequences. The fitting together of a series of crops to give sufficient time between crops to allow for seasonal variations in growing time without keeping the house in unprofitable use is not an easy subject on which to give advice. Climatic variations in different parts of the country alter the times and the most profitable time of maturity may vary with different markets and in different years. In spite of this, the studies at the Stations can give growers a guide to the suitability of different crops for growing in mobiles and make a substantial contribution to our knowledge of the behaviour of crops under these conditions.

Lettuce

As in static houses, lettuce is the most common overwintering crop in mobiles, but there is more flexibility in fitting the crop into a mobile rotation than into that of a static house. Good crops of lettuce can be cut in April in the south, May in the north, if protection is given from the time of planting in November–December until mid-February or later, provided a non-tinting variety is grown. May Princess, May Beauty, Premier and Westlandia have proved good varieties for uncovering. May Queen, which browns when uncovered, is only of use if protection is given until completion of cutting. Early uncovering allows such crops as direct-planted, early flowering chrysanthemums, a second crop of lettuce, strawberries, tulips or French beans to follow winter lettuce, practices which would either not be possible or would result in the crops which follow being later in static houses. The earlier the crop is uncovered, the later it matures. Lettuce can also be intercropped with the follow crop and sweet peas, gladioli and cauliflowers have all been tried. At Efford, lettuce and sweet peas appeared to fit in well together. The lettuce occupied space in the early life of the sweet pea crop which was required later for movement between rows once stringing was done. It is probable that self-cropping with lettuce is often more profitable than having two crops, lettuce and cauliflowers, together. With short-life crops, a remunerative late summer or autumn crop is always the most difficult to find. A lettuce crop sown in the open in late July and covered in September can be cleared in November in time for planting another lettuce crop to overwinter.

A lettuce-chrysanthemum rotation has proved very profitable at both Stockbridge House and Luddington. At Stockbridge two crops of lettuce and three of chrysanthemums have been covered during the year for the essential periods of their life. Special attention has been paid to the selection and grouping of chrysanthemum varieties in order to harvest the three crops without overlapping at flowering time.

Dwarf Beans

Although these can be fitted into the cold mobile sequence as a summer crop, it is unlikely that this is economic. At Luddington, sowings made as early as April or as late as July produced crops with very low returns. Production costs are also very low and the profit margin is not large enough to be attractive. With heat to push them earlier or later, the picture might well be different.

Tomatoes

The tomato crop requires coverage during the whole of its life. In using a mobile house, there is no need to give a winter flooding and the site can be prepared for the crop before the house is moved over it. The mobility of the house enables different sites to be used in succeeding years, thus reducing the incidence of soil-borne pests and diseases. Though soil sterilization cannot always be avoided, the need for it becomes less frequent than in a static house. The use of resistant root stocks to overcome soil-borne troubles may, however, reduce this latter advantage of the mobile house.

A common cropping sequence is lettuce, tomato, chrysanthemum. If the house is moved from the lettuce at the end of March, it does not matter leaving some of the lettuce to be harvested from the open and, if the weather is favourable, soil temperature rises in readiness for planting tomatoes. Mid-April is a reasonable planting date in most areas, but where the soil is warm enough the earlier in April the plants are set out the earlier and heavier will be the crop. At the other end of the rotation, chrysanthemums can be direct planted in the open and the house moved over them in late September, thus avoiding lifting the crop to house it or carrying pots into the house after having grown the plants in the open.

Other Vegetable Crops

The use of cauliflowers as an intercrop for lettuce has already been mentioned. Coverage of these cauliflowers until the end of lettuce cutting will give an earlier curd, but the economics are doubtful as the advantage of early uncovering of lettuce on the succeeding crop is lost.

The raising of pot cauliflower plants in cold glasshouses is a common practice in some areas. The plants occupy the house from mid-November to mid-March and may be a useful winter crop, allowing good time for movement over to the tomato site or for tomatoes to follow on the same site. There would appear to be little advantage for this crop over a static house, except that hardening off is easier.

Chrysanthemums

This crop fits in well with the mobile system, using direct planting and, for some seasons, late-struck cutting techniques. The two flowering periods which are most popular and, usually, most profitable, are July and October. For July flowering, cuttings are taken in early March and planted in the glasshouse at the beginning of April. This is a good crop to follow lettuce. In most seasons the earliest blooms make the most money and at Luddington a comparison was made of the economics of producing the crop from single-stem plants spaced at 6 × 4 in. and stopped plants, taking three blooms per plant, spaced at 9 × 8 in. Both methods with a full stand give 54 blooms per sq yd of bed. The single-stem plants flower 7–14 days earlier than the stopped plants, but have to make an average of 2*d.* per bloom more to pay for the extra cuttings at 3*d.* per cutting. They do not do so and the growing of the earliest-flowering varieties, stopping about a fortnight after planting, appears to be the more economic. Varieties which have done well at several Stations are the Sweethearts, White Hope Valley, Milestone, Delightful and its sport.

The profitability of the October flowering crop appears to be to some extent dependent on the ability of the plant to throw laterals when grown on a natural-break system, and varieties differ in this respect. Cuttings are normally taken in mid-April and planted out towards the end of May at 12 × 9 in., the plants being covered in September. Stopping at the end of June of plants which have not produced a break bud will help to force laterals. The aim is to produce over 70 good blooms per sq yd of bed. Varieties which have done well at this season are Arundel, Orange Stuart Ogg, Amy Shoesmith, Bill Walters, Snowcap and Marie Brunton. The last two, although not particularly free in throwing breaks, make very good prices per bloom and reach the top for this reason. At Rosewarne, a comparison has been made between late-struck cuttings and the method described above. Cuttings taken in early June are planted in early July, stopped once and 3–4 blooms per plant taken. Generally, they flowered about a week later than the same varieties grown from March cuttings. This is important as, in poor seasons, the quality of the crop can quickly deteriorate in unheated houses as the season advances into November. November flowering crops have been successful at the southern stations, Efford and Rosewarne, although the danger of petal damage is always present. At Efford, Loveliness, and at Rosewarne, the Wallace varieties, have been particularly good at this season. These varieties must be stopped to produce the best results.

Flower Crops Grown as Annuals

Many flower crops have been grown in cold mobile rotations and some of the short-life crops, e.g., those which mature in 12–16 weeks from sowing or planting, are particularly useful. Low labour requirements are also a valuable feature of some crops.

The crop with the shortest growing period, as short as ten weeks, is probably column stocks, planted out. Day-length and temperature requirements for flowering makes timing important, though there are no precise means of controlling these factors in this method of growing and the aim is for May to July flowering, when days are long and temperatures high. Plants raised in heat and hardened off may be planted in the second half of March and suitable varieties

will be cleared by the end of May. Direct-sown crops occupy the house for longer, from 14–16 weeks. The earliest date of sowing is possibly mid-March, with cutting starting in about 10 weeks from drilling. A 100 per cent double strain is used. Dark green seedlings, which will be single-flowered, are easily recognized and discarded when pricking off the crop for planting-out, or when thinning the direct-drilled crop. Comparisons of spacing have been made at Rosewarne. Quality has suffered at 4 × 4 in., and 6 × 4 in. or wider was better. Further work on the costs and returns from various spacings remains to be done.

Zinnias have been grown at a number of centres and are a good 12–14 week crop, drilled *in situ*. Their profitability was dependent upon earliness. Both at Efford, selling in London, and at Luddington, selling in midland markets, prices fell after early July and it is generally concluded that only crops which finish by mid-July are worth while. Studies at Luddington indicate that 10 May is about the latest date of sowing to give reasonable price returns and the earlier the better. Following lettuce, late April sowing is possible; following cauliflower plants, it can be done in late March. The large-flowered types have been most successful. Although the Lilliput types are prolific, so many flowers are required to make a bunch that bunching costs are high, with returns per unit area about the same. Both planting out and stopping have been tried at Rosewarne, but direct drilling, using 1 oz seed to approximately 250 ft of row and no thinning, appears to be the cheapest and most satifactory method.

Gypsophila elegans has been grown at Rosewarne. Sowing *in situ* in early February, with some thinning of seedlings, appeared to be the best method. The house was cleared in late May. Wallflowers and larkspurs have been covered from just before flowering until the end of cutting and flower quality has been improved by this practice. The period of use tends to interfere with the coverage of more remunerative crops and the economics are doubtful except in exceptional cases. Sweet peas have been used at Efford as an intercrop with lettuce. Cuthbertson varieties in a range of suitable colours have been grown. Sweet peas can be sown in the open *in situ* in October, or tray-sown and planted out with lettuce. The lettuce are cleared during April and the sweet peas continued until prices drop to too low a level, usually towards the end of June. At Rosewarne, where sweet peas have been grown as a self crop, the variety Elizabeth Taylor has done well. Covering is not done until April, when the plants are ready for stringing. Here it was concluded that it was more economic to scrap the crop when it had reached the top of the supports and to move the house to another crop rather than extend the flowering of the sweet peas by layering. Myosotis instead of lettuce has been used as an intercrop at Efford. Timing this crop to mature just before Easter appeared to find a good market and allowed the crop to be cleared for the sweet peas to continue growth satisfactorily.

Bulbs and Corms

These crops are of particular interest in the south-west and most of the work described has been done at Rosewarne, although some bulb crops have been grown at Efford and Stockbridge House. Details of timing derived from Rosewarne work may not apply in less favoured areas.

There are two methods of growing narcissus for mobile house production, one treating the crop as an annual one, the other as a perennial three-year crop. In

the first case bulbs are planted in September, touching as in boxes for forcing, and with the noses of the bulbs level with the top of the soil. Covering with straw 6 in. deep or with lath screens helps to keep the temperature lower after planting, which is important in early flower production. Covering in December allows blooms to be marketed in February or March, or covering can be left as late as early March. Leaves are cut with the flowers and used to back the bunches, and bulbs are discarded after one crop. In perennial crops, wider planting, 4 × 4 in. or 4 × 6 in. is practised and the crop is treated as an outdoor one except that the crop is covered for flowering. The economics of this method have not been worked out. The high cost of bulbs makes the annual crop, with less than two marketable flowers per bulb, a doubtful economic proposition for cold houses if bulbs have to be purchased. Many holdings in the south-west have bulbs of their own, making the practice attractive. Among the advantages of the mobile house coverage over some other systems of forwarding bulbs is the elimination of watering.

Tulips, using such varieties as Krelage's Triumph and Golden Harvest, can be forwarded under unheated mobiles in the same way as narcissus, although results are much more satisfactory under heated glass. Planted in October and covered in November, the flowering period will be mid-February to mid-March planted a month later, covered in mid-January, they will flower in late March or April; covered in mid-March they will flower in early April.

Anemones, planted in mid-July and covered from mid-November to mid-March, and cleared by the end of April, proved satisfactory at Efford. Earlier crops were obtained at Rosewarne, but were not of good quality.

Muscari has been grown as a perennial crop at Rosewarne. Coverage was provided in late January and advanced flowering over outside crops by a few weeks. The earliest varieties bloomed in late February, others in early March. Poor demand might make this crop unprofitable. Iris has also been successfully grown in mobile rotations.

Of the summer bulbs, gladiolus is the most important. Gladiolus for early flowering are commonly planted in the structure in early March, sometimes interplanted with lettuce. The mobile house is moved off the crop in late May after the lettuce have been cut and the risk of frosts is past and flowering is outside, or is left in position over the flower crop until it is harvested. The possibility of producing a late crop has been investigated at Rosewarne. Late-flowering varieties were used and corms were kept in a cool place to retard sprouting until they were planted at the end of May. On one section, strawing down and frequent damping of the straw to induce low temperatures was done in an attempt to delay flowering. Delay of about a week was, in fact, achieved, but botrytis incidence was high and it is not thought that the method is an improvement. Plants were covered early in September at the commencement of flowering, which continued until mid-October on the unstrawed plots. On another site, unstrawed plants were covered in mid-July. These were relatively free from botrytis and flowered from the beginning of September to early October. It may be that later planting and covering from mid-July onwards will be a satisfactory method. Freesias are another crop which require some heat to give the best results. Early sowings give the best results, but even with April or May sowing there is a risk of frost damage at flowering time without some heat. Covering after seed-sowing has been investigated at Rosewarne and lath screens,

kept in position from the time of sowing until the crop was covered by the glasshouse in mid-September, have shown promise. Mulches of straw or peat have tended to depress yields. *Schizostylis*, *Ranunculus* and *Montbretia* have also been tried, but without marked success.

Perennial Flowers

There is a range of perennials which might fit into mobile rotations, but few have been investigated. Delphiniums, using the Belladonna hybrids and Pink Sensation, look promising. Covered in early April, good spikes can be cut in late April and May and a second crop from late May to September. Mildew is a problem on the pink variety, but dinocap is an effective control. Christmas roses and perennial carnations of the French type, des Fleuristes, are other possibly successful crops.

Strawberries

This crop does not appear generally suitable for mobile houses. Successful crops have been grown at Efford and at Stockbridge House, but in the south the crop under cloches was better, being heavier from less leafy plants, and at Stockbridge, where picking finished in mid-June, the range of profitable crops to follow was very limited.

Several studies were made at Efford combining the use of low Dutch light frames with a mobile house to extend the period of coverage for some crops and increase the number of protected crops in the rotation. This method was highly successful with some rotations so far as the production of crops was concerned, but the high cost of movement of the frames on and off crops and for cultural operations makes the economic value doubtful. The studies have been discontinued for this reason.

Economic and cultural studies on various crops and rotations are being continued.

Further information on the crops grown has been published in the Station Reports or is available on request to the Director of the Station concerned.

SHORT NOTES ON OTHER EXPERIMENTAL WORK

METHOD OF STRAW DISPOSAL IN AN ARABLE ROTATION

Experiments, designed to compare the effects on crop yields and soil fertility of four different methods of handling of the straw grown in a six-course rotation, have now been in progress for twelve years on four Experimental Husbandry Farms. The four methods of straw disposal are:

1. straw removed;
2. straw burnt;
3. straw ploughed in (with nitrogen at the rate of 15 units per ton of straw ploughed in);
4. straw removed and 12 tons FYM per acre applied to the potato crop (P&K dressings are adjusted to compensate for P&K content in dung).

In each straw disposal treatment the crops of the six-course rotation are grown at two levels of nitrogenous manuring.

The experiments are in progress at Boxworth (heavy clay), Gleadthorpe (light sand), High Mowthorpe (chalky loam) and Terrington (silty loam). In all cases, potatoes and sugar beet are grown as the first and fourth crops of the rotation with two cereal crops in between. The experimental plan was such that all crops of the rotation are represented in duplicate each year for each of the eight straw treatment/nitrogen rate combinations. The results to date are most conveniently examined crop by crop, and then in terms of soil organic matter. In this appraisal of crop yields the "straw removed" treatment is regarded as the "control".

Potatoes (all Farms). At the low level of nitrogenous manuring (80 units per acre) the FYM dressing has increased yield by up to 10 per cent but, at a higher rate of nitrogenous manuring (120 units per acre), this difference has been largely eliminated. On the lighter soils straw ploughed in has caused some yield increase, again more noticeable at the lower level of nitrogen manuring. Yields after burnt straw are similar to those after carted straw.

Winter wheat (all Farms). Since this crop follows potatoes there is no direct effect of straw treatments. There is a residual benefit of the FYM given to the preceding potatoes of some 4–6 per cent and this appears to be independent of nitrogen levels where, on average, 30 and 70 units have been compared. The second year residual benefits of straw ploughed in and burnt have been very small, except for low-nitrogen plots at Gleadthorpe.

Spring cereals. Barley at Boxworth and Gleadthorpe has benefited from ploughed in straw at the low level of nitrogen manuring (20 units per acre) to the extent of some 15–20 per cent, but the difference is eliminated at 60 units of nitrogen per acre. A similar situation occurs in the spring oats at High Mowthorpe and Terrington. Yields after straw burning are similar to those after carted straw in all cases, and there are comparatively small second year residual benefits from FYM to potatoes at the low rate of nitrogen only.

Sugar beet (all Farms). At all Farms, except Terrington, burnt and ploughed in straw and the residual effect of FYM to potatoes show yield increases over carted straw to the extent of some 8 per cent at the low rate of nitrogen (60 units per acre), but once again the differences disappear at Boxworth and Gleadthorpe at 100 units of nitrogen per acre. The difference is maintained at High Mowthorpe. At Terrington the only effect is a depression of 10 per cent due to straw burning.

Wheat. Spring wheat is the fifth crop at Boxworth and High Mowthorpe and winter wheat at Gleadthorpe and Terrington. Small benefits due to the various straw treatments are seen at the low level of nitrogen (35 units per acre), but again these vanish at the higher level of 70 units per acre.

Spring barley (all Farms except Boxworth, which has spring oats). Straw ploughed in at the low level of nitrogen manuring (25 units per acre) causes a small increase in yield, but there is no difference in the straw treatment yields at 60 units of nitrogen per acre.

The crop yield effects may well be summarized by saying that there are some benefits in returning the straw to the land either as FYM to potatoes, or by ploughing in when crops are grown at a low level of nitrogen manuring, but that the yield of crops grown after straw removal, or indeed after straw burning at a medium to high level of nitrogenous manuring, can equal the yields obtained after returning organic matter to the soil.

Soil organic matter. Some assessment has been made of the levels of soil organic matter throughout the course of these trials and it is clear that differences now are only marginally greater than they were early in this trial. In the case of Boxworth and High Mowthorpe there has been a general downward trend, at Gleadthorpe a slight upward trend after FYM and ploughed in straw, and there appears to have been little or no change at Terrington.

R. Wickens

LONG-TERM EFFECTS OF WEEDKILLER SPRAYS FOR CEREALS

By 1951, the use of "hormone" (translocated) contact sprays for controlling weeds in cereal crops, had become universal, but little was known about the possible long-term effects of repeated annual doses of these chemicals. Consequently, it was decided that a permanent trial would be laid down at Bridget's Experimental Husbandry Farm to pick up any such effects, if they appeared. The cropping for the trial would be an all-arable rotation, including a high proportion of cereals, to give maximum opportunity for spray application. In the nine years, 1951–59, seven cereal crops were grown, with potatoes and kale as break crops. The spray treatments were: no spraying, M.C.P.A., 2,4-D or D.N.C. applied at normal rates. These materials were chosen as then being in current popular use.

The plots were harvested separately and yields recorded each year. In general, the different sprays neither increased nor depressed yield, with the exception of D.N.C., which reduced the yield of S.172 winter oats by 13 cwt per acre in the first year of the experiment.

Weed seedling counts were carried out before spraying in 1955, 1956, 1959 and 1961, in order to detect any changes due to previous treatments. The first three counts showed that populations of fat hen and thistles were reduced by spraying, but seedlings of charlock, chickweed, docks, bindweed, grass and knotgrass occurred as much on sprayed plots as on the control. The 1961 count, following potatoes in 1960, revealed that, not only were there smaller numbers of fat hen and thistles on the sprayed plots, but there had also been a reduction in charlock and knotgrass populations by this time.

In 1960, samples of potatoes were examined for taint, discoloration and other

cooking characteristics by the Ministry of Agriculture, Fisheries and Food's Food Laboratory. This testing revealed no effect of treatments. In the same season, Advisory Entomologists recorded soil populations of wireworms, millipedes, centipedes and other arthropods and found that there were no variations caused by spray treatments. Advisory Bacteriologists made cultures of the soil bacteria and found that the sprayed plots appeared to contain a mixed flora, part of which required for maximum growth the complex factors such as are present in yeast and soil extracts, whereas the controls contained a flora with relatively simple nutritional requirements.

In 1960, the trial was reviewed, simplified and brought up-to-date by the changing of some of the spraying treatments. 2,4-D was discarded and the plots that had received it in the past became a second MCPA treatment; DNC was superseded by mecoprop (CMPP.) In 1961 and 1962, barley was grown on the trial. In both years spraying with MCPA produced a yield increase compared with the control; in 1962 it amounted to 4·1 cwt per acre. The effect of mecoprop was not so consistent, yield being depressed by 3·9 cwt in 1960 and raised by 1·3 cwt in 1961. However, these early results must be regarded as provisional.

Weed counts made before spraying in 1962 confirmed the trends noted in the previous year; populations of fat hen, thistles, charlock and knotgrass had all been reduced by spraying. In addition, there was now evidence of less bindweed on all sprayed plots and less chickweed on plots sprayed with mecoprop. Counts were also carried out after spraying and showed the same trends as those made before spraying, the degree of reduction of susceptible weeds being much the same, with the exception of chickweed, where the immediate effect of mecoprop was to reduce the population still further. The most obvious difference between plots has been the build-up of thistles on the unsprayed treatment during 1961 and 1962. This made thorough stubble cultivations and double-ploughing necessary in the autumn of 1962.

During 1962, the trial was sampled monthly for soil bacteria, organic carbon and nitrate estimations, and bi-monthly for soil fauna counts. It is hoped that these detailed studies will establish whether any real changes are taking place. Samples of grain are being held for future possible estimations of toxic residues.

So far, over 11 years, this trial has not brought to light any disadvantages resulting from the frequent use of weedkiller sprays, either from the point of view of crop growth or because of the appearance of other undesirable features. It is intended to continue the trial until 1966, at least.

S. P. McClean

DIRECT AND RESIDUAL EFFECTS OF PHOSPHORUS FERTILIZERS ON YIELDS OF ARABLE CROPS

A long-term experiment, designed to test the direct and residual effects of four phosphorus fertilizers on the yield of arable crops, has now been in progress on six Husbandry Farms for a sufficient length of time to allow some conclusions to be drawn.

The soils of two of the Farms, Rosemaund and Trawscoed, are classed as acid and those of the others, Boxworth, Bridget's, Gleadthorpe and High Mowthorpe, as neutral.

The four fertilizers are superphosphate, rock phosphate, basic slag and dicalcium phosphate. Each fertilizer is applied either as a single triennial dressing at the rate of 60 or 120 units P_2O_5 per acre or as three separate annual dressings of 20 or 40 units per acre.

The results from the direct application of phosphatic fertilizers are similar to those obtained from numerous annual experiments. The acid soils at Trawscoed and Rosemaund are more responsive than on the other four Farms on neutral or alkaline soils. At some of the Farms large responses were obtained on potatoes and root crops but at all Farms the response by barley was small. In general, superphosphate proved to be the most effective fertilizer, particularly at the lower rates of application, whilst rock phosphate was least effective.

Dicalcium phosphate, at the highest rate (120 units P_2O_5/acre) on potatoes, is the only example of a less soluble phosphate giving higher yields than superphosphate at the same rate. This occurred on five of the six Farms. Rock phosphate had little value compared with superphosphate on the neutral soils and showed its greatest effect on swedes and kale on the acid soils. There is evidence, especially with potatoes, that the efficiency of rock phosphate decreases more rapidly with increased dressings than does that of the other fertilizers.

All the fertilizers gave residual effects one and two years after application. These effects were greater in the first than in the second year. The fertilizers giving the largest response in the year of application tended to give the larger residual response. At Trawscoed, however, rock phosphate gave larger residual effects on swedes than the other fertilizers, although the effect of the direct application of superphosphate was greater. The efficiency of residues varied from crop to crop and was least for potatoes. There is some evidence to suggest that residues can produce an effect on yield in the presence of fresh dressings of fertilizer.

The results of these experiments indicate that phosphorus fertilizers are more efficiently used if they are applied to the more responsive root crops in a rotation, rather than in smaller annual dressings to all crops. Thus, for example at Trawscoed on the most responsive soil, 80 units of P_2O_5 per acre to potatoes and swedes and none to barley and clover in a four-course rotation is a better proposition than 40 units per acre to each crop. In the former case, potato yields are increased by 1·2 tons/acre and swede yields by 0·4 tons dry matter/acre; barley and clover yields are maintained by residual effects.

A more detailed account of these interim results will be found in Experimental Husbandry, 8 (1962), pp. 85-103.

Rice Williams

MANURING OF SWEDES AND KALE IN THE SOUTH-WEST UPLANDS

It is difficult in the South-west uplands to provide good quality grass from the beginning of January to the end of March, a time when pregnant ewes and out-wintering cattle need to be fed well. Kales and swedes are possible alternatives for this period. Manurial experiments on these crops were carried out at Liscombe Experimental Husbandry Farm from 1959 to 1961.

Swedes

Large responses were obtained from phosphate fertilizer and the results of a

series of phosphate applications indicated that a dressing of 100 units P_2O_5/acre is necessary to ensure a full crop.

An excellent response was also obtained from potash. The results were rather more variable than with phosphate and the initial soil analysis gave no indication of the amount of potash that ought to be applied. It is thought that, over the years, 100 units K_2O/acre can be profitably used.

There was a small response to nitrogen fertilizer but the increase in yield would not be economic at the present time. It may be worth while, however, to include a low level of nitrogen to stimulate early growth and, consequently, make inter-row cultivation of the crop easier.

Kale

Variety trials on the Farm have shown Canson kale to be the most useful variety for utilization from January to March. The experiments were based on variations of husbandry and the use of nitrogen to exploit this variety. All the kale plots received a standard fertilizer dressing of 100 units/acre of P_2O_5 and K_2O.

Better yields can be obtained from this crop if it is sown early in May rather than June or later, and 90 units N/acre will give a good return. The results did not suggest that seedbed, top-dressed or split fertilizer applications were at all different in their effects and a practical method would seem to be the application of a nominal amount of nitrogen in the seedbed, for example, 30 units N/acre, and to apply up to 60 units as a top dressing if the crop is about average. There was some evidence to suggest that a maximum yield of 50 cwt/acre of dry matter is the best that can be expected from the variety when grown in the South-west uplands, and that, in a very favourable season, the top dressing of nitrogen may not be justified.

The value of growing these root crops lies in the feed that can be utilized. Current studies with yearling cattle and sheep suggest that one acre of kale or swedes that are grazed *in situ* can be replaced by approximately 6 tons of silage. In this situation, the case for growing root crops, for late winter use in a climate that can grow grass well, may depend upon varities yielding more than those used in these experiments.

D. B. J. Thompson

LIQUID FERTILIZERS FOR AGRICULTURAL CROPS

For the last three seasons farmers, in at least some parts of the country, have been offered fertilizers in liquid form. Until 1962 these liquids have consisted of simple solutions of some or all of the following chemicals—urea, ammonium nitrate, ammonium phosphate and muriate of potash. In this form, the liquid fertilizers are less concentrated than the most recently introduced granular compounds, but certain advantages have been claimed for them, most of which derive from the ability of liquids to be pumped through pipes. Thus, it is claimed, the handling of sacks is eliminated and accurate placement of the fertilizer in the soil is readily possible. During 1962 more concentrated liquids, in which fertilizer ingredients are held in suspension, have been introduced, but neither these nor gas liquor, are the subject of this note.

During the last two seasons, liquid fertilizers have been compared with solid

fertilizers in trials at Bridget's, Gleadthorpe, High Mowthorpe and Terrington Experimental Husbandry Farms. At Bridget's in 1962, a 20 per cent N. liquid was compared with sulphate of ammonia and Nitro-Chalk at two rates, and at four times of application, as a broadcast top dressings for winter wheat. Solid fertilizers were broadcast by hand; liquid fertilizer was sprayed on the crop with a special high volume crop sprayer. No wheeling was made on any treatment, the sprayer being driven with its wheels in discard areas. In this cold year, liquid fertilizer gave a slightly higher yield than sulphate of ammonia when each was applied at 60 units N/acre, but both yielded similarly at the level of 80 units N/acre. Neither material performed as well as Nitro-Chalk at either rate on this chalky soil.

A trial at High Mowthorpe on spring barley in 1962, compared the application of compound fertilizers supplying 60 units N, 30 units P_2O_5 and 30 units K_2O, as solid broadcast or combine drilled or as liquid fertilizer sprayed on the seedbed or injected into it. The yields from the four systems did not differ. When, however, the liquid fertilizer was sprayed on the growing crop six weeks after drilling, the yield of barley was less than that after early application.

At Gleadthorpe and at Terrington, liquid and solid fertilizers are being compared for the potato crop. Working with Majestics, the Terrington trials have compared the two types of fertilizer at two rates, when both were sideband placed. This comparison was achieved by sideband placing the solid fertilizer with the planter, and by injecting the liquid fertilizer into the sides of the baulks after planting with a special applicator which placed it 2 in. to the side and 1 in. below the sett, as nearly as possible in the same position as the solid fertilizer was placed. In 1961, when the liquid fertilizer was applied three weeks after planting (and consequently three weeks later than the solid fertilizer), it gave lower yields than did the solid. In 1962, when both types of fertilizers were applied on the same day, the yields were the same.

At Gleadthorpe in 1962, liquid and solid fertilizers were compared for early potatoes at one rate of application. Solid fertilizers were either broadcast before planting or placed in the ridge near the tubers, while the liquid was either sprayed on the surface before planting or injected into the side of the baulks immediately after planting. Comparing similar methods of placement, the two types of fertilizer gave similar yields.

As liquids can be injected into the baulks after planting, the effect of delaying application until after planting was examined at Terrington in both 1961 and 1962. Under certain conditions, a divorce of planting and fertilizer application might avoid delays in planting and thus lead to higher yields. In 1961, a season of late planting and rather dry seedbed conditions, delaying application of the fertilizer caused a reduction in yield. In the different conditions of 1962, when the potatoes were planted early into an ideal seedbed but, when subsequent growth was very slow owing to the cold weather, a delay of even 30 days after planting (from 23 March to 24 April) caused no reduction in yield.

At Gleadthorpe, liquid nitrogenous fertilizer, sideband placed for Canson Kale after early potatoes, is being compared with broadcast Nitro-Chalk each at 30 and 60 units N/acre. No results are available at the time of writing.

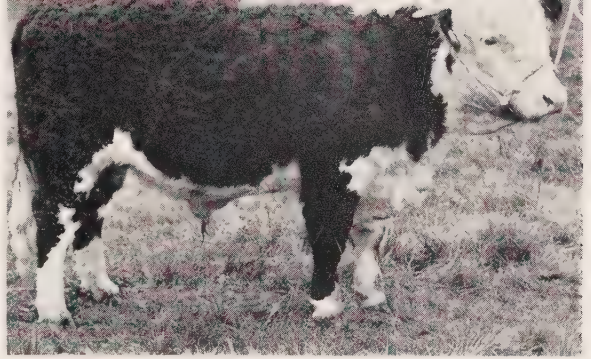
It would be wrong to attempt to draw detailed conclusions from this very limited data. Under certain conditions, liquid fertilizers appear to be quite as effective as the traditional solid fertilizers. In three instances, they have been

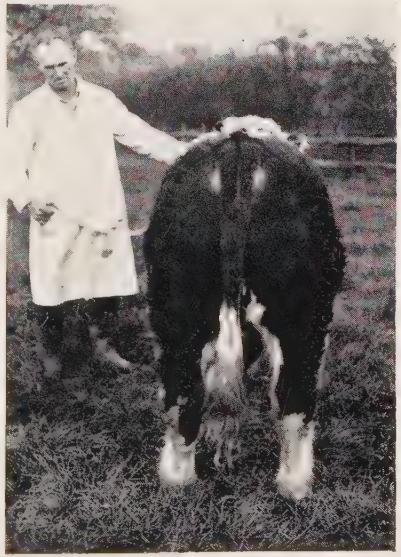
GLEADTHORPE EXPERIMENTAL HUSBANDRY FARM
Ley Fertility Experiment: grazed leys (treatment sequence) and emerging potatoes (first test crop)

Left:
Crimper with interlocking steel rollers

Right:
Roller crusher with grooved rollers of reinforced rubber

BRIDGET'S EXPERIMENTAL HUSBANDRY FARM
Detail of Hay conditioning machinery
PLATE I





ROSEMAUND EXPERIMENTAL
HUSBANDRY FARM

Progeny Test on Beef Bulls

Left: Bull above average in rate of gain and in visual merit placing

Right: Bull below average in rate of gain and in visual merit placing

PLATE II

Photos: Farmer and Stockbreeder

Above: Storage cabinets with accurate control of temperature and humidity for bulb conditioning experiments

Right: Rear view of same cabinets

ROSEWARNE EXPERIMENTAL HORTICULTURE STATION
PLATE III

KIRTON EXPERIMENTAL HUSBANDRY FARM

Experiment in forcing of Narcissus. Boxes held at different temperatures for rooting. On left 48°F, centre 56°F, right 60°F. All boxes received uniform treatment in forcing house.

LEE VALLEY EXPERIMENTAL HORTICULTURE STATIONS

Mobile glasshouse with ducted hot air heating for an experimental crop of freesias.

PLATE IV

less effective: when compared with the better of two types of solid fertilizer (Bridget's, winter wheat) or when applied later than the normally accepted time of application (High Mowthorpe, spring barley and Terrington 1961, maincrop potatoes). The Terrington work in 1962 suggests that, under certain circumstances, a delay in application may cause no reduction in yield and this could prove to be an advantage. Claims for other advantages in farm organization, which are made for liquid fertilizers, do not lend themselves to test in replicated field trials.

F. E. Shotton

CEREAL ROOT EELWORM

Land which is heavily cropped with cereals is liable to become infested with Cereal Root Eelworm. Oats suffer more severely from this pest than other cereals, but barley may be badly affected when the infestation is heavy. The eelworm feeds on the roots which then become inefficient: fresh rootlets take their place, which in turn are damaged and, thus, the root system becomes a dense and bushy mass of short roots in contrast to the long and relatively unbranched system of a healthy plant. In extreme cases the leaves are stunted and turn yellow with red or purple tinting at the tips. These symptoms do not assist very much in diagnosis since many nutritional disorders, e.g., acidity or bad drainage, can produce a similar appearance.

In 1953–54, serious damage from eelworm was reported from many parts of the country, and at Gleadthorpe Experimental Husbandry Farm a field where oat failures had been recorded from time to time was found to be heavily infested. In conjunction with the Advisory Entomologists, a rotation experiment was therefore started on this site to find out how changes in eelworm numbers in the soil were influenced by the system of cropping. In the first three years of the experiment, the number of eelworms increased greatly where oats were grown continuously, and at the end of this period they were two or three times as numerous as where oats were taken every second or third year with break crops of mangolds or clover.

The effect of this contrast in eelworm infestation showed itself in oat yields during the next five years. On average, the oats grown every year with 15 units/acre of bag nitrogen yielded only half as much as the rotational oats, although the continuous oats did have the advantage of a small dressing of dung, which was not given to the oats following break crops. Where the oats were more generously manured with nitrogen, the continuous oats yielded relatively rather better at about two thirds of the yield of the rotational oats.

During this time, however, eelworm numbers declined on all treatments and relatively more so on the plots carrying oats every year. This does not necessarily signify that the fall in population followed a consistent trend, but rather that, in the soil conditions encountered during those particular seasons, eelworms could not multiply beyond a certain level or "ceiling" as entomologists term it. The more rapid reduction in numbers, where oats were grown continuously, evidently occurred because the crops were so poor that the eelworms were starved. By 1961, differences in soil environment due to treatments had diminished to the extent that the amount of infestation was fairly uniform whatever the cropping sequence, there now being only about a third as many eelworms

as had been found at the start of the experiment in 1955. But in 1962 the continuous oats still only gave 37 per cent on the yield of the oats grown in rotation. This suggests that eelworm is not the only cause of the low yields of oats grown continuously. Weeds are certainly a problem where oats are taken every year but, being largely controlled by spraying, they can hardly affect production to that extent.

One theory is that continuous oat growing encourages the build up of parasitic organisms, perhaps viruses, which depress plant growth. Whatever the reason, it is clearly risky to grow oats too frequently on land liable to sudden increases in eelworm numbers. However, the temptation to do so is much less than in the case of barley, which fortunately is less susceptible to eelworm damage. An interesting feature of recent cereal breeding work is that certain new barley varieties do show some resistance to cereal root eelworm. At Gleadthorpe, for example, in three years out of four the variety Kron outyielded Proctor on land known to be infested with root eelworm, whereas, on clean land Proctor did better, as it almost invariably has done, when the two varieties were tested together in the National Institute of Agricultural Botany variety trials. The contrast was very evident in 1959, when the infestation after harvest on the area cropped with Kron was no worse than it had been before the barley was drilled, whereas it had multiplied four-fold during the season where Proctor had been grown. At present the most profitable varieties to grow under normal conditions do not show exceptional resistance, but it may be that in the future the breeder will succeed in combining high commercial performance with resistance to this pest. Such a variety would be worthwhile growing on land carrying even a light infestation in order to keep the population of eelworms below the level at which crop damage occurs.

P. N. Harvey

SERVICE LIFE OF TREATED AND UNTREATED ROUND FENCING TIMBER

Joint trials with the Forestry Commission began at eleven Experimental Husbandry Farms in 1958 to determine the useful life of various peeled and pointed round fencing posts.

At all sites, a comparison is being made between untreated posts and posts treated with either creosote or a proprietary fluor-chrome-arsenate water-borne preservative. Non-leaching copper-chrome-arsenic preservatives, now used for wood in contact with the ground, were not available for hot and cold treatment at the time the trial was started. Treatment was by an open tank hot and cold immersion method. Scots pine was chosen as a standard species at all centres and compared with a hardwood species available locally. In northern England this was sycamore, in Wales birch, while at the remaining Farms alder, ash or elm were used.

The trial consists of driving the posts into the ground for 1 ft 6 in. of their 5 ft 6 in. length, and annually after erection applying a standard horizontal test pull of 50 lb to the top of each. A record is made of the number of posts in each treatment group failing at each annual test. The conclusions below are based on the tests applied up to three years after erection.

The results to date demonstrate the superior durability of treated over untreated posts. After three years of service, 100 per cent of creosote treated and 95 per cent of the water-borne preservative treated posts remain sound, but only 46 per cent of the untreated posts have survived.

Alder, although only tested at one site which has a low rainfall, has been a noticeable failure when not treated, no posts having survived the second annual test. Untreated Scots pine and birch, too, show a poor survival rate after three years. Untreated ash, however, at three sites still retains 75 per cent survival after three years.

As expected, high rainfall has had the effect of retarding the rate of decay. For example, only 7 per cent of untreated Scots pine has failed at the two sites having a rainfall of more than 60 in. per year, compared with 54 per cent failure over the remaining nine sites with lower rainfall.

In a subsidiary test at one site it has been found that charring the point of ash stakes has had no preservative effect.

A more detailed account of these trials will be found in Report on Forest Research for year ending March 1962.

J. R. Aaron

ALL-CONCENTRATE FEEDING IN BEEF PRODUCTION

Recent work at the Rowett Research Institute has highlighted the possibility in beef production in this country of feeding considerably higher amounts of concentrate than had been the practice. This technique is being studied at a number of Husbandry Farms and an assessment is being made of its local value as a tool in beef production. The main factors that will affect the commercial value of the technique are the type and cost of animal that is used and the amount and cost of concentrate needed.

Effect of Animal

It can be seen from the table that the performance of the Friesian steer may be better than any of the crosses but, within the Friesian steers used, there is most definitely a need to select for a high growth rate to make full use of the concentrate that is to be fed. The data on Friesian steers at Liscombe and Boxworth relates to a selection of the best of a bunch, and the high conversion rates and liveweight gain there show the advantage that can be gained by careful selection of stock to be put on this method of feeding. There were indications that the better animals could be selected from a population on the basis of their live weights at, for example, 10–14 weeks of age. As yet, the data collected has not been subjected to any analysis to examine correlations between weights at any given age and subsequent performance, and there is room for work in this field. Animals, with anything but the highest growth potential, can probably be fed a cheaper ration than an *ad lib* concentrate one. When animals are fed from birth to slaughter on an all-concentrate diet, a difference of 0·1 in conversion rate will mean a difference of approximately 80 lb of food eaten.

Effect of Age on Conversion Rate

The data in the table (p. 38) shows that the older animals had, as might be expected, a much poorer conversion rate of food into liveweight increase than young

Performance of animals on all-concentrate diet

Farm	Number and sex	Breed	Age (weeks) Initial	Age (weeks) Final	Live weight (lb) Initial	Live weight (lb) Final	Live weight gain (lb/day)	Feed consumed (cwt/head)	Feed conversion (cwt/head)	Carcass wt. lb	K.O. percentage
Gleadthorpe	10 Steers	Friesian	12	51	219	961	2·7	34·4	5·4	550	57·0
Boxworth	(a) 6 Steers	Friesian	1	49	99	931	2·4	30·8	4·1	519	55·7
	(b) 3 Heifers	Friesian	0	49	73	690	1·9	—	—	Not yet slaughtered	
Liscombe	(a) 9 Steers	Devon × Friesian	31	60	307	859	2·7	27·2	5·5	489	56·9
	(b) 6 Steers	Devon × Friesian	28	59	341	866	2·4	26·2	5·6	499	57·6
	(c) 6 Steers	Devon × Friesian	78	90	947	1,143	2·3	13·4	7·7	673	58·9
	(d) 7 Steers	Friesian	10	43	225	911	3·0	26·2	4·3	517	56·8
High Mowthorpe	15 Steers	Friesian	14	43	262	824	2·8	26·2	5·3	Some animals not yet slaughtered	
Rosemaund	(a) 9 Steers	Friesian	12	52	204	899	2·5	—	—	Not yet slaughtered	
	(b) 6 Steers	Hereford × Friesian	12	52	188	845	2·3	—	—	”	” ”

NOTES: (i) Boxworth (a) and Liscombe (d) are a selected sample of animals
(ii) Liscombe (a) animals had suffered severely from husk while at grass and showed excellent recovery.

animals. This same effect was noticed within each of the groups, namely, that as the animals increased in age their conversion efficiency decreased. In the current market situation, slaughter at about 850–900 lb live weight is probably the most economic time. This decision is based on the assumption that, at the 900 lb mark, each two pounds of live weight is yielding just over one pound of carcass meat, but more information on the validity of this assumption is required. Perhaps the biggest factor influencing the decision to slaughter at this weight is the degree of finish. A difference of two units in killing-out percentage will mean a difference of 18 lb of carcass meat from a 900 lb animal.

Although the general opinion is that young animals of high growth potential are necessary for this system of feeding, it is possible that a situation could arise, for example, a poor store market, when a farmer could with advantage finish stores on an all-concentrate diet, even though a low conversion rate was experienced.

Type of Feed

The basis of all the feeding on the Farms has been a high proportion of barley. Some Farms have thought already that barley can be substituted by other feeds. For example, in a new trial at Boxworth, 50 per cent of the barley is being replaced by wheat and, at Liscombe, when barley prices were high, maize was included quite satisfactorily up to 30 per cent of the ration.

It is essential to ensure that the concentrate to be fed is accurately made up. The animals at Rosemaund went blind for a spell and their performance dropped. This was attributed to a deficiency of vitamin A. Vitamin A has been included, but the additive was stale and the potency of the vitamin probably reduced.

About 30 cwt of concentrate will be needed to feed an animal from 200 lb live weight to slaughter. If barley is the principal constituent of the feed, a difference of £2 per ton in the cost of the barley will mean a difference of approximately £2 10*s*. 0*d*. in the cost of production of one animal.

At Experimental Husbandry Farms in grassland areas there is a natural interest in combining the use of barley with grass and grass products. While to date an all-concentrate ration has been used to finish animals that were reared at grass, in current work at Liscombe, the possibility is being examined of using concentrate feed when the animal is young and its conversion rate is good, and using good quality grass as the feed later in life when the conversion ratio is poorest.

Carcass Quality

The reaction to the carcasses obtained from all-concentrate feeding have invariably been very favourable. It would seem likely that a market can be developed for the white fat and pink flesh that concentrate feeding produces. This carcass is always obtained from a ration containing a high proportion of barley, but it may not be obtained if other feeds are substituted for the barley. The effect of substitution of feeds on the quality of carcass produced will have to be carefully watched.

Health

On most of the Farms it was not possible completely to cut out straw from

the animals' diet. At Boxworth, they were initially bedded down on wood shavings and, with the complete removal of long fibre feed, there were some cases of bloat. At Rosemaund, two animals died of bloat when young and, at High Mowthorpe, the death of one animal was caused by a digestive disturbance. No bloat occurred when animals were bedded on straw at Boxworth; experience has been similar at Liscombe and Gleadthorpe. At Rosemaund, where the most trouble in this respect occurred, it is thought that one pound of hay a day may be a necessary and sufficient preventative. Shortly after changing to all-concentrate feeding, some calves at High Mowthorpe suffered from severe respiratory trouble, and four animals of a group of nineteen had to be taken from the all-concentrate feeding. It is difficult to attribute this ill-health directly to all-concentrate feeding, but it has been suggested that, if the food is dusty, then respiratory troubles may develop.

It was found that animals will change quite quickly to an all-concentrate feed from grass, but the evidence obtained indicates that the performance of the animal is not at first as good as the quantity of concentrate eaten suggests it ought to be. The change is probably best made over a 5–6 week period. No health troubles have been experienced at the Husbandry Farms in this change-over period, but commercially, troubles have been recorded and, while new barley is suggested as a possible reason, it may be that the sudden change to a high intake of barley has contributed to the deaths that have been reported from Yorkshire and also experienced elsewhere. When slaughtered, severe cases of abscesses in the liver and kidneys of apparently healthy animals were frequently noted.

Conclusion

In an enterprise that produces beef from all-concentrate diets, it must be expected that profit will come from a low margin per animal but a high throughput of stock. Experience at Husbandry Farms has been concerned with only small groups of animals and the results that have been obtained show that skill is needed to select the right calves, to rear these calves, and to feed them a well-compounded concentrate.

It is suggested that the all-concentrate feeder would welcome information on which he could cull stock from this system at an early age, and also the extent to which he can substitute other feeds for barley without affecting the animal's performance and the quality of the carcass.

The problems that may be associated with keeping large numbers of stock on this system have not been considered.

D. B. J. Thompson

CARCASS ASSESSMENT AT ROSEMAUND

From the beginning, the cattle experiments at Rosemaund have concerned beef cattle taken through to slaughter. Evaluation of the carcasses required both facilities to work and sufficient knowledge to use the subjective assessments made in the butchery trade. These requirements were readily met by the Fatstock Marketing Corporation, the Birmingham Co-operative Society and the College of Food Technology in London. A panel of the Ministry's meat graders also judged the carcasses at the slaughterhouse.

For six years, while dealing with "Beef from the Dairy Herd," the programme was as follows:

At the slaughterhouse the head, feet, caul and gut fat, heart, liver, tail and hide were weighed. Taking precautions to avoid loss during slaughter and handling, the rumen, reticulum, omasum, abomasum and intestines were weighed when full, then emptied, cleaned and re-weighed. The differences between the two gave the weight of gut contents from which differences in "fill" could be determined and an "empty weight" calculated for each animal.

Certain carcass measurements were made three or four hours after slaughter. These were the length of back, hind leg, twist, radius and ulna and tibia, together with thickness of thigh, buttock girth and depth, and depth of thorax. Full length photographs of the right side of each carcass were taken against a portable backcloth carrying a 6 in. grid to show both the inside and outside views, and provide permanent visual reference to the conformation and finish.

The grading panel scored the carcasses for the following points.

Conformation in terms of compactness, thickness of fleshing and amount of bone for the whole side. The loin, rump, round, shank, ribs and chuck, brisket and flank, neck and shin were then assessed as separate joints.

Finish in terms of amount of exterior and interior fat cover, kidney and cod fat.

Quality as colour and texture of flesh, colour of fat and marbling of the eye muscle after quartering at the tenth rib. Finally an overall general score was given before the carcass was graded in the usual way.

The right sides of the carcasses were sent to Birmingham and the left sides to London, where they were cut into the wholesale joints appropriate to the region and weighed as wholesale joints. For a time in Birmingham it was also possible to send the right sides through a pre-packaging plant, where the wholesale joints were weighed complete before breaking down into saleable meat, surplus fat and bone. If followed by cooking and tasting tests, this is the ultimate measure of carcass value; unfortunately, such breakdown is only possible when the experimental carcasses and their number suit a particular plant and market.

In London, Mr. Frank Gerrard, then Head of the Meat Department, College of Food Technology, scored the left side by eye and cut it into wholesale joints. Students then carefully separated the meat from the bone of the shin and shank. It was hoped that the meat to bone ratio of these two cheap joints would prove to be an index of the meat to bone ratio of the whole carcass.

On both sides of the carcass the length and depth of the eye muscle and the thickness of fat above it was measured at the tenth rib. This was then photographed under standard conditions so that the areas of the eye muscles of different sides could be compared.

A cooking and tasting test was also done in London. A ten pound rib roll from the 8th and 9th ribs was cooked in a uniform way and then submitted to a tasting panel for comments on "degree of doneness", juiciness and flavour.

The type and range of animals used in this work has been too limited for firm conclusions to be drawn, but the inference is that there is no cheap "indicator" joint nor any simple combination of carcass measurements which will fully predict the "acceptability" of the carcass.

J. R. Kellam

FEEDING COWS AT GRASS

Two series of trials at Bridget's Experimental Husbandry Farm provide

valuable information on economy in concentrate feeding when milking cows are at grass. In the first series, the period May-early July was examined and the late summer period of July-September was studied in the second series.

The results of the first series of trials, comparing three supplementary feeding treatments on spring calving Ayrshire cows grazing grass, have been recently published in Experimental Husbandry 7, 1962, pp. 45-55. These experiments were conducted from 1956 to 1959: four seasons in which cows averaging $4\frac{1}{2}$–5 gal per day were used to compare:

1. no supplementary feeding;
2. 7 lb per head of barley meal;
3. 7 lb per head of balanced dairy concentrates.

The cows were on the treatment rations from the time they went out to grass by day and night until the beginning of July. They were given 2–3 lb of rough hay to control bloat and also fed 1 lb of a mixture of barley and linseed cake containing calcined magnesite. Milk yield, quality, and live weight of the cows were recorded during both the treatment period in May and June and during July to September, when all the cows were fed standard rations to examine any residual effects.

Only in one year, 1957, when the quantity and quality of spring grass was considerably below average, was supplementary feeding in May and June economically justified by higher yields during the whole summer. In this season, balanced concentrates gave a greater return than barley meal. In the other three years, neither barley nor dairy concentrates produced any worthwhile response during May and June, nor did they improve yields in late summer.

On average, milk quality showed little effect from either form of supplementary feeding. Butter fat was not significantly affected in 1956, 1957 or 1958, but in 1959, when luxuriant grass containing a high nitrogen content was available, both supplements prevented a drop in butter fat percentage, balanced concentrates being most effective. Solids-not-fat content of the milk was not significantly affected in any year. In all years, the cows receiving barley or concentrates gained most weight during the May and June period, but there was no real difference in the weight of any group of cows by the end of the summer.

The conclusion drawn from this first series of trials was that supplementary feeding in May and June to cows yielding 5 or even 6 gal a day was not profitable, unless grass was scarce or of poor quality. When there is a risk of low butter fat percentage, balanced concentrates may prevent the drop, although this was shown only in 1959, when unusually luxuriant herbage was being grazed. It should be borne in mind, however, that the cows in this trial were fed 2–3 lb of hay; if it had not been fed, milk quality may have been more affected by supplementary feeding.

The second series of experiments investigating feeding in the late summer period, July, August and September, was started in 1960 and has continued to 1962. Spring calving Ayrshires, which had previously been fed for over maintenance and four gallons in May and June, were used. The three treatments compared feeding balanced concentrates at $3\frac{3}{4}$ lb/gal for production over:

1. maintenance + $4\frac{1}{2}$ gal (low feeding);
2. maintenance + 3 gal (medium feeding);
3. maintenance + $1\frac{1}{2}$ gal (high feeding).

All the cows were fed approximately 3 lb hay as a precaution against bloat and all received 2 lb barley tying-up ration which contained calcined magnesite to guard against hypomagnesaemia.

In none of the three years have either of the two higher rates of feeding increased milk yields. When grass was scarce and of poor quality, a slight increase in yield occurred during July and early August, but even during this time the cost of concentrates was not repaid by the extra milk produced. If full use is not made of grazing and dairy concentrates are fed for below 4½ gal, large sums of money are spent on concentrates for no yield increase, as can be seen below.

Cost of concentrates per cow fed July-September (mean 1960-62)

	£	s.	d.
1. Maintenance + 4½ gal (low feeding)	0	7	7
2. Maintenance + 3 „ (medium feeding)	3	5	2
3. Maintenance + 1½ „ (high feeding)	8	18	9

Milk quality and cow live weight are the other important factors involved. Butterfat percentage has been little affected: under medium feeding, butterfat tended to be slightly higher, but under high feeding this increase has only occurred in one year (1960). Solids-not-fat content has been highest under medium and high feeding in two years (1960 and 1962), but there was no significant effect in 1961.

During the three years, the mean live weights of cows on all treatments have increased by approximately ½ cwt from July to September, and medium and high feeding have not resulted in consistently greater live weight gains compared with low feeding.

Briefly, grazing in late summer was able to provide maintenance and 4½ gal, milk yield was not improved by feeding more concentrates and any improvement in milk quality that sometimes occurred could be achieved by feeding after the third gallon.

The results of these two series of trials are very important financially, for the most common factor which causes low profit in the dairy herd is excessive use of concentrates. These trials have proved that good grazing can produce 5 or even 6 gal in May and June and 4½ gal from July to September and there is rarely justification for feeding concentrates below these levels.

M. Hastings

PELLETING FOOD FOR PIGS

There have been several reports claiming improved efficiency of conversion in pigs when the food is fed in the form of a pellet or nut rather than as a meal. These statements have been based in the main on observations rather than on critical trials. It was assumed by the majority of pig feeders that the difference, if its existed, was due to the wasteful feeding of meal, especially a dry meal which is liable to be blown or pushed out of the trough by the pigs.

An experiment was started in 1959 on three of the Experimental Husbandry Farms, Boxworth, Bridget's and Great House, to compare the two systems of feeding. Initially three treatments were used at Bridget's and Great House and these were as follows:

1. meal fed dry;
2. meal fed wet;
3. pellets.

At Boxworth only, treatments 1 and 3 were used. The meal was pelleted either without additives, such as molasses, or where molasses was added it was included in both the meal and pellets to ensure that the energy value was not altered. Adjustments were made in the weights fed to correct for any changes in dry matter between the pellets and meal. At Boxworth, the pigs were slaughtered at 130 lb and at Great House and Bridget's at 200 lb live weight.

Some early results had to be discarded when it was found that the analyses of the pellets and meal were not identical. This was due to the variability in the cereals used.

There have now been sufficient reliable results at Boxworth and Great House to indicate that the pelleted feed gives a better conversion rate and quicker live weight gains than the meal. Even if the meal could be fed with the same low level of wastage as the pellets, the feed conversion figure for the latter would still be superior. There were variable results at Bridget's, however, and at this centre there appeared to be little to choose between the treatments.

In order to test whether the difference is due to the physical condition of the feed or to some other cause, the dry meal treatment at Great House was replaced by one in which the meal was pelleted and then reduced to a meal again for feeding. The second experiment was therefore composed of the following treatments:

1. meal;
2. pellets;
3. pellets reduced to a meal.

There are insufficient completed trials in the second experiment, but those which have been finished indicate that the treatment in which pellets were reduced to a meal is as efficient as the pellets and more efficient than the original meal. This suggests that the pelleting process may improve the digestibility of the ration, possibly due to the higher temperatures evolved when compression is applied to the meal.

C. H. Mudd

POULTRY RATIONS

It is commonly reckoned that the food bill represents about two-thirds of the total cost of producing eggs. A typical laying ration contains about 60 per cent of cereals which can be made up from home-grown wheat, oats and barley, or from imported maize.

On farms where cereals are grown, it generally pays to feed them to livestock, including poultry, and this applies particularly to barley at the present time. For the poultry keeper who buys all his feedingstuffs, barley is the most attractively priced home-grown cereal and it is generally cheaper than maize, although the margin between the cost of the two grains naturally fluctuates according to market supply and demand. From the nutritive point of view, barley provides less energy than maize and the question is whether hens will lay on a low energy diet, largely consisting of barley, as well as they do on a ration based on maize which is less fibrous and higher in energy producing value.

Work at the Poultry Research Centre at Edinburgh showed that, provided the protein content of the ration were adjusted to its energy level, egg production was as good on a low energy mash based on oats and barley as on a high energy mash compounded from wheat and maize. This was because the birds fed on the low energy diet satisfied their maintenance and production requirements by eating more food than those receiving the high energy ration.

During the past two seasons this work was repeated with pullets housed in batteries at Gleadthorpe and Great House Experimental Husbandry Farms. In these trials, a laying mash containing 60 per cent barley was compared with one containing 60 per cent maize. The protein supplement, consisting of soya bean meal, white fish meal and grass meal, was formulated so that the protein content of the barley mash was 13–14 per cent and of the maize mash, 16-17 per cent. The nutritive ratio, representing the relation between protein content and energy value, was 3·9 : 1 for both rations.

At Gleadthorpe, averaging both years for a 44-week laying period, egg production per bird housed was 206 on barley mash and 205 on maize mash, an almost identical performance. The pullets ate 12½ per cent more barley mash, which must therefore be cheaper by at least the same proportion, than maize mash to show a worthwhile economic advantage. The price comparison between the two rations depends of course on the relative costs of barley and maize. With barley at £20 per ton and maize meal at £26 per ton, the rations cost £26 10*s.* 0*d.* and £31 per ton, respectively, including a charge for milling and mixing. At these prices barley mash is about 14½ per cent less expensive than maize mash, a saving which slightly more than offsets the higher consumption by the pullets. It is noteworthy that, although in the first year the birds were light laying crosses and in the second light heavy crosses, the relation between the amounts of the two mashes consumed per pound of eggs was almost the same in the two years.

At Great House, where a light laying cross was used in both years, the high energy diet showed to better advantage. Over a 44-week laying period, egg production per bird housed averaged 206 on maize mash as compared with 192 on barley mash, and the pullets ate only 2 per cent more of the low energy ration. Since this Farm does not grow barley, all feedingstuffs in the two rations were purchased and, taking into account the relative costs of the two mashes, there was a small financial advantage in favour of the high energy maize ration.

The widest difference in egg production between the two groups occurred in cold weather, when the birds needed more energy for body heat, and this was also the experience at Gleadthorpe, when groups of heavy and light laying crosses were fed these two rations in a deep litter house: with the onset of cold and humid conditions, production from the pullets fed on the low energy mash was depressed more than from those which received the high energy mash: this was especially the case with the lighter type of bird.

It seems that high energy rations, although more expensive, are justified for light birds with small appetites, particularly if they are housed in uninsulated deep litter houses or straw yards where uniform conditions of temperature and humidity are difficult to maintain. Also high energy rations require less storage space and less labour in feeding. With good control of atmospheric conditions, and with the heavier birds capable of eating enough of a bulky diet to satisfy

their needs, low energy rations based on barley can give equally good results at less cost, especially if the barley is grown on the farm.

P. N. Harvey

EARLY SUMMER CAULIFLOWER

Summer cauliflower is an important crop in the programme of experiments at Luddington. It was found that in work done in collaboration with the National Vegetable Research Station an excellent crop of cauliflowers could be grown by planting when the soil was as near to field capacity as possible, and afterwards applying 1 in. of water by irrigation, each time a soil moisture deficit of 1 in. had been reached. This treatment might not be possible where there was a shortage in the supply of water, equipment or labour and it is therefore important to find out how to get the maximum benefit from limited irrigation.

With this in view and bearing in mind the results of experiments at the National Vegetable Research Station, a new irrigation trial was started at Luddington in 1962. Cauliflowers were planted at 1 ft, 2 ft and 3 ft square and irrigation treatments were given after planting:

a no water;
b 1 in. at 1 in. SMD;
c 1 in. about 10 days before cutting.

Generally speaking, findings confirmed those from the National Vegetable Research Station. Regular irrigation had a great beneficial effect on the crops grown at 1 and 2 ft square; the single watering before cutting was not as good, but was still valuable and much better than no water at all. At the 3ft spacing the benefits from irrigation were much reduced and a worthwhile crop was grown without any water being applied. (See following table.)

Irrigation of early summer cauliflower, Luddington 1962

Spacing (ft)	Not irrigated	1 in. water at 1 in. SMD	1 in. water 10 days before cutting
	Crates per acre		
1×1	25	1330	793
2×2	139	616	365
3×3	247	344	297
	Per cent curds browned		
1×1	87	0	22
2×2	57	2	30
3×3	15	1	3
	Gross market return (£ per acre)		
1×1	18	1134	681
2×2	119	503	313
3×3	203	257	234

In the first year of the trial, curd size decreased as the number of plants per acre increased, but with irrigation closer planting made the crops more valuable. Where no irrigation was given, severe curd browning was a most important factor and reduced marketable yield.

The developing curds were evidently damaged through the plant being unable to obtain sufficient moisture during periods of rapid water loss. As in previous dry years, restoring the soil to field capacity each time one inch deficit had been reached, prevented the trouble. Though the single watering before harvest reduced the incidence of curd browning, it was still serious under that treatment except at the widest spacing.

On the unwatered plots, increasing the spacing decreased the number of browned curds, but there was still about one-seventh of the crop damaged at the widest spacing.

A. R. Carter

SELF BLANCHING CELERY

The small scale market gardener is often at a disadvantage compared with his large scale neighbour, particularly from the point of view of land and machinery. However, one crop in which the former excels is self blanching celery. This is a very demanding crop which is often grown to perfection by the small grower possessing only the basic equipment of modern horticulture, viz., heated propagating space, irrigation equipment, fertile soil and the ability to pay particular attention to an intensive small area. It can be grown without the specialized heavy machinery used by the trench celery growers in the Fens or the Lancashire mosslands, and does not require such a highly organic, deep soil. Best results are likely to be produced on well bodied land of high fertility, but the most important factor for satisfactory growth is a readily available supply of water. In some cases, this is present as a high water table which the roots are able to reach soon after planting out, but usually water must be supplied artificially by overhead irrigation. Total water requirements are high and experience suggests that an average application throughout the growing period of $\frac{3}{4}$ to 1 in. per week is not excessive.

Experiments on various aspects of growing outdoor self blanching celery have been conducted at Stockbridge House for the past seven years, and the emphasis has been on the production of early crops of first class quality. Demand for this vegetable in late July and August is high and, by the correct choice of varieties and management of the crop, this demand can be met with rewarding results. Past variety trials have shown the suitability of Golden Self Blanching for an early harvest, particularly the stocks of Pinetree Nurseries and Tozer. The season may be extended by growing Golden Marvel (Clucas) for a mid-season cut, whilst Lathom Blanching (Clucas) produces heads of excellent size, quality and flavour for September and October. A new variety trial began in 1962 comparing eighteen different stocks and, although only one season's results are yet available, a new early, Newburgh Golden (Clucas), looks very promising. Attempts have also been made to grow New Dwarf White (Clucas) as a self blanching type. This variety is popular with the maincrop growers of trench celery because of its high quality for lifting from October to December. Unfortunately, the trials here were unsuccessful, since the blanching did not reach an acceptable level even at spacings of 9 × 9 in., although tenderness and flavour were excellent.

Most seedsmen are now warm-water treating celery seed to control leaf spot, a disease which is carried over from one season to the next on the surface of the seed-coat. It is a simple operation for the grower to do this treatment for himself

or to repeat it to make absolutely sure that the seed is clean. Double treatment, however, will cause some reduction in germination and allowance must be made for this at sowing.

Propagation experiments have shown the value of fast and unchecked growth during the early stages of the life of celery plants. For the earliest outdoor crops, there is little to be gained by sowing before 6 March, provided that the young plants can be grown on at a temperature not lower than 55°F (13°C). Earlier sowings, combined with lower propagation temperatures, tend to produce plants which are more susceptible to bolting. Sowing is done in a temperature of 60°F (15°C), using full boxes of John Innes seed compost. The seed should be sown (3–4 seeds per sq in.) on to the top of the compost, or at the most lightly covered with coarse sand. The boxes are then covered either with glass plus brown paper, or with black polythene. Celery seeds are slow to germinate, and the surface of the compost should therefore not be allowed to dry out. The covers should be removed as soon as the seeds have germinated.

Various containers have been compared for pricking-off the seedlings, and the best results have been obtained from soil blocks and compressed peat pots, provided they are not allowed to dry out. Plants pricked out into boxes have also cropped well. A slight increase in yield was produced by using J.I.P.2 compost at pricking out compared with J.I.P.1. Plants from a 6 March sowing are usually large enough to prick off by the first few days in April, and they should remain in a temperature of 55°F (13°C) for about three weeks. The plants may then be transferred to a closed, cold frame and gradually hardened off by receiving increasing ventilation until they are finally uncovered. This brings the plants to a critical stage in their life; if they are allowed to remain in their pricked off quarters for too long, they become checked by competition for water and nutrients and begin to lose outer leaves. On the other hand, if they are planted out and suffer a cold spell, there is a risk of bolting later. However, for the last four years, very early plantings outside at Stockbridge House (e.g., during the first few days in May) have been completely successful with a negligible amount of bolting even after the abnormally cold May in 1962. A note of caution must be sounded here regarding early plantings. Growers would be well advised not to plant up at a very early stage a larger area than they are certain to be able to market early. If plants from an early planting are left to become overcrowded at harvest time, then the risk of bolting is increased and breakdown of the outer leaf stalks is rapid. Optimum plant spacing has been found to be 10 × 10 in. giving about 62,000 plants per acre.

Experience at Stockbridge House has demonstrated the value of watering in plants immediately after planting in the field. A suggested practicable routine is to plant during the day and apply about $\frac{1}{4}$ in. irrigation during the evening. In this way, the plants will not be checked and will continue to grow. The need to maintain an adequate supply of water during the growing season has already been mentioned, and it cannot be over-emphasized. A generous fertilizer programme must be adopted to encourage rapid growth and a base dressing of a high nitrogen/potash compound at about $\frac{1}{2}$ ton per acre is recommended. Rates and frequencies of top dressings and methods of application vary with circumstances and the condition of the crop. The practice at Stockbridge House is to apply granulated fertilizer, broadcast by hand and washed off immediately by irrigation. Straight nitrogen is given a month after planting at 50 units per acre

followed a month later by a compound fertilizer, applying 65 units or thereabouts each of nitrogen and potash. This second application is made as late as possible, but before the density of the crop makes it impossible for workers to walk through without causing damage.

One other interesting line of work at Stockbridge House involves a breeding programme started in 1957 using Canadian Utah celery as one parent. This variety is stringless and tender, and possesses excellent eating qualities. In this country, however, it meets considerable market resistance because the petioles will not blanch and the plant remains green. The object of this breeding work is to combine the superior flesh and flavour qualities of the Green Utah with the blanching characteristics of the standard self-blanching types. Similar work is being undertaken by the Plant Breeding Section at the National Vegetable Research Station and, although it is too early yet for any line to become "fixed" so that it breeds true, some promising material has already been produced and tested.

It is possible that, by the time an acceptable fixed line emerges from this breeding programme, the public will have become educated to eat the North American green celery. This was first grown at Stockbridge House six years ago, but the markets would not accept the produce. In the 1962 variety trial, four of the American green stringless varieties were included and the size of stick as well as quality was far superior to the standard self-blanching types for cutting at the end of August. The first consignment met the inevitable market resistance, but towards the end of the harvesting season salesmen and public were showing considerable interest. If the housewife can be convinced that this green celery is edible, then it could soon replace the traditional self-blanching types.

A. Loughton

FREESIA TEMPERATURE STUDIES

Work with freesias at the Lee Valley Experimental Horticulture Station is primarily concerned with the factors that affect earliness and flower quality of the seed-raised crop. Two cultural techniques are being compared—growing in containers and direct in the soil of a mobile glasshouse; the nutritional requirements of the crop are also being studied. Work has also begun on the application of recent research in the Netherlands on the heat treatment of corms. It is hoped that better ways may be developed of using the corms that can be saved from a seed-raised crop. It is too early to comment on these aspects of the experiment, so this report will be mainly confined to a consideration of the effect of temperature, a field in which the work has reached a more advanced stage.

Flower initiation in the young seed-raised freesia plant is largely governed by temperature. The critical level has been established by work in Denmark as being about 60°F (15°C); at mean daily temperatures above this level flower initiation can be delayed, and at excessively high temperatures flowering may be prevented altogether. Conversely, at temperatures below the critical level, the initiation of flowers is promoted and earlier flowering results.

Although freesia plants require cool conditions for flower initiation, plenty of warmth should be given in the early stages, for it is essential that a strong plant is

established which will then be capable of bearing good quality flowers on long stems.

After germination the plants always go through a purely vegetative phase: it is only when they have reached a height of about 4-6 in. that they are capable of initiating flowers, providing the average temperature is below about 60°F (15°C). Flowering commences about 10-12 weeks after initiation. The best results can then be obtained by growing the plants under warm conditions until 10-12 weeks before the first flowers are required. Thereafter, any treatment that prevents excessively high temperatures will tend to promote flowering.

At Hoddesdon the plants were kept cool by means of a dense shading of coir netting (hop lewing) erected over the plants when they were 4-6 in. high, and arranged about 1 ft above the plants; the shading was raised as the plants grew in height. Half of the crop was shaded for 9 weeks from the end of June to the end of August, the other half remaining unshaded. The crop was also sown on two dates; one half on 5 May, the other on 30 May. The effects that sowing date and shading had on the time of marketing of the crop can be seen from the following table.

TABLE I

Freesias: numbers of flowers picked 1961-62

Sown		1 Nov. to 9 Feb.	10 Feb. to 30 Mar.	Totals on 30 Mar.
May 5	Shaded	196	99	295
	No shade	136	147	282
May 30	Shaded	117	143	259
	No shade	79	199	278
	Means	132	147	278

The earlier sowing date resulted in earlier flowering. This may have been due in part to the longer growing period and partly because earlier sowing enabled the plants to initiate flowers before hot weather arrived.

By 9 February, when half the total crop had been marketed, the position was as follows:

Sown 5 May 30 spikes marketed
„ 30 „ 18 „ „

Plants sown on 5 May had thus produced 66 per cent more spikes than the plants sown on 30 May.

It can also be seen that shading had a marked effect on the earliness of the crop. On 9 February:

Shaded plants 29 spikes marketed
Unshaded plants 19 „ „

Shading increased the number of spikes market by 9 February by over 50 per cent.

It can be seen, therefore, that the best results can be obtained by sowing as early as weather permits, and by shading whenever there is a period of hot

weather between June and the end of August. It might be expected that the use of a dense shading, such as coir netting, might reduce the yield and quality of the flowers. However, if the right-hand column in Table 1 is examined, it will be seen that the shaded plants gave the same yield as those unshaded. No adverse effect on flower quality was observed.

The results of this experiment confirm work that has been done in Denmark and the Netherlands. There are other means of reducing the temperature around the plants in the summer besides using coir netting. Hessian, cheese cloth or fish netting (double thickness) can be used, or the plants can be given frequent but light overhead sprays by hose or irrigation lines.

Shading, or one of the other methods mentioned can thus help overcome one of the main difficulties which arises with freesia grown from seed: the unpredictability of the timing of the crop from one year to another. The crops grown at Hoddesdon serve as an extreme example of the variation that can occur.

Season	*Sowing*	*Peak of marketing*
1961–2	Early May 1961	end February
1962–3	Early May 1962	early November

The difference of about 14 weeks between the peaks of marketing the crops in these successive seasons can be attributed to climatic variations.

In the 1961-62 season there was a period of high temperatures in June and July 1961, which caused a delay in flower initiation. The summer of 1962 was unusually cool. The low temperatures led to premature flower initiation, and flowering from the end of September onwards. At the same time, the plants were so slow in becoming established that these early flowers were borne on very small plants, and were thus too short in the stem to be marketable. These examples demonstrate the need for some form of a cooling treatment in a warm summer, and also the undesirability of giving shading as a routine treatment. If the 1962-63 crop had been shaded, it would have caused an even greater loss in quality.

However, it should be pointed out that in both seasons the date of sowing was rather late as the seed was sown in the open. Good quality early crops could have been ensured by sowing in April in some form of container in a glasshouse or frame. The plants could then have been moved to the flowering site towards the end of May, either by standing out the containers or by transplanting the seedlings. In 1961, flower initiation might well have occurred before the advent of hot weather, and in 1962, the plants could have made more growth before the flowers were formed, thus avoiding the wastage due to premature initiation and the resultant short stems and poor quality flowers.

Early sowing of freesias, combined with warmth in the early stages and cool conditions during the summer, can thus help to ensure that early flowering is obtained.

J. Whetman

BREEDING WINTER CAULIFLOWER VARIETIES

A breeding programme is being undertaken with winter cauliflower (broccoli) at Rosewarne Experimental Horticulture Station, in conjunction with the National Vegetable Research Station, to breed new varieties, principally for

use in the South-west. The object is to produce varieties that will mature in this area in January, February and March when cauliflower production is of particular economic importance.

The material for this work was derived from two sources. First, the Gulval strains originating from a small number of December–January heading Roscoff types which were developed at the Gulval Experimental Station, near Penzance (now closed), and, secondly, a larger collection of February–March Roscoff strains which were developed in the Southampton area by the then Cambridge Horticultural Research Station and were subsequently transferred to the N.V.R.S. Most of the material was collected together in the 1940s, but at that time no facilities were available to undertake a detailed programme of selection and further breeding.

The present methods involve:

1. inbreeding of all the various "families" for two or more generations;
2. progeny testing these inbred lines;
3. selection of the most promising, followed by
4. hybridising to produce F_1 hybrids between the selected inbreds.

Progeny testing is felt to be an all-important section of the work, and rather than rely on selection by eye, detailed records are kept of yield, quality, frost resistance, ringspot resistance and other factors.

Facts emerging so far show that the inbred lines segregate very satisfactorily into different types. The aim is to select for curds which are 4–6 in. in diameter, semi-spherical in shape and of a good density. They should be entirely free from such quality defects as bracting, riciness and looseness, and have adequate leaf protection.

Variation in vegetative types, maturity range and curd types are relatively easy to distinguish at the inbred stage, and a primary selection is made based on those families which contain a high proportion of the desirable characters. From these promising families, the very best individuals are then selected as potential parents for F_1 hybrids. It is extremely important that the individual plants selected should come from families containing a high percentage of good quality heads rather than selection of one or two good plants from an otherwise poor or mediocre family.

Most of the original clones have now been inbred, and many have been discarded due to insufficiently high quality, and to a certain extent loss of vigour, although at this stage reduction in vigour alone should not be considered as a limiting factor. This is likely to be restored when the hybridization (F_1) stage is reached.

Selected mature plants from the field are transferred to a glasshouse for seeding, and serious problems of stem rotting and other diseases arise at this stage, often making it difficult to grow the plants right through to seed harvest. All selfing is now done as bud-pollination, this method giving the most satisfactory seed set. Cross pollination is also carried out at the bud stage using the emasculation technique of removing the stamens to prevent self pollination from taking place. In addition, selected lines are propagated vegetatively, by curd cuttings to enable individual clones to be maintained indefinitely.

The breeding of winter cauliflower is also being undertaken at Efford Experimental Horticulture Station in Hampshire and Stockbridge House Experimental Horticulture Station in Yorkshire.

At Efford, using similar basic material to Rosewarne, the work is being concentrated on the March maturity period. A number of promising lines have been selected for suitability to the south coast, and particular attention is being paid to achieving winter hardiness and a very short harvest period.

At Stockbridge House, the aim has been to improve the uniformity of stocks grown in the West Riding. It is felt important to do this without sacrificing the winter hardiness which growers have successfully achieved by their own selection and seed saving over many years. Selection has been made with a view to fixing such characters as shortness of plant on the stalk, and a leathery texture of the leaves which should also be of good colour and well covered with wax. Adequate curd protection by the leaves is important, though mature heads could be missed by the cutters if obscured completely by the inner leaves.

Audrey M. Williams

PROMISING NEW VARIETIES OF FRUIT

One of the questions most frequently asked by growers visiting the National Fruit Trials is, "What are the best new varieties to plant?" It is not possible to give a complete answer to this question because the trials of tree fruits at Brogdale have not been established long enough to determine the potential merits of the new or newer varieties and, even if they had been, it would not always follow that a variety showing promise here would do as well elsewhere. In any trial, spraying, manuring, etc., must be as uniform as possible for results between different varieties to be comparable, so the new varieties in each group are tested against a recognized standard and treated in the same way. Late dessert apples are compared with Cox's Orange Pippin on which a considerable amount of research and experiment has been carried out over many years. If as much were known about the requirements of the new varieties as is known about Cox the former might be treated very differently and might give better results than in present trials. Uniformity of treatment, however, is inherent in any exact trial and this should not be lost sight of when weighing up the potentials of a new variety.

It has been found that at least 95 per cent of the new varieties received for trial are no better than, and often inferior to, existing commercial varieties, and it follows that the National Fruit Trials are dissuading growers from planting varieties which would eventually prove to be of little commercial value. Equally important, and this is a point which is often overlooked, should a new variety of really outstanding promise be discovered every other year the industry would soon be in a state of chaos from not knowing what to choose from. Any new variety must therefore be of outstanding merit, superior in quality to an existing commercial variety or extending the season by either picking very early or keeping very late. The varieties which are to be mentioned must *not* be regarded as proved commercial varieties, but only as showing promise at an early stage in their trial history, and it does not necessarily follow that they will maintain their promise, as will be shown by one of the apples to be described.

Apples

A new early dessert apple is needed to replace Beauty of Bath which is of poor quality and retains its freshness for a very short period only. An apple of this

season which is attracting some attention is Stark Earliest, raised in America and introduced by Stark Brothers Nurseries. The fruit is of medium size to medium small, $2\frac{1}{4} \times 2$ in. rounded and slightly angular. The ground colour is ivory, half to three-quarters flushed and striped with scarlet. The flesh is off-white, moderately juicy, slightly sweet and of fair flavour. The stalk is of medium length. Stark Earliest ripens at approximately the same time as Beauty of Bath and the fruit will keep in condition for a slightly longer period.

Tree growth is moderately vigorous and cropping up to the present has been regular, but the set is so heavy that it is necessary to thin in order to get good size. The variety is susceptible to mildew. It would appear that the colour of the fruit is not fixed as it varies considerably. In some cases completely flushed fruits, completely striped fruits or a combination of flushed and striped can be found on the same tree, while some trees produce nothing but striped fruit. From this variability arose the so-called sport Scarlet Pimpernel which is indistinguishable from Stark Earliest under Brogdale conditions.

We also need an apple to fill the season between Beauty of Bath and Miller's Seedling or Tydeman's Early Worcester, and the variety George Cave may possibly fill this gap. This is a chance seedling. The fruit is medium to medium small, $2\frac{1}{4} \times 2$ in. round-conical, pale yellow green with a diffused orange red flush on the side next to the sun and carmine stripes. The flesh is white, fine, crisp and of pleasant flavour. The stalk is moderately long and extends beyond the base of the fruit.

Tree growth is moderately vigorous and cropping is regular and heavy. On young trees the fruit may not colour too well, but this fault can be overcome by using a pre-harvest spray. George Cave comes at a time when there is a demand for a red apple (after the Granny Smith and Golden Delicious season) and so far it has sold well. Like the previous variety, it may need thinning if good size is required.

A heavy cropping variety to supplement Cox's Orange Pippin could be a useful acquisition and also one after Cox in season of marketing. A few years ago it was thought that Kidd's Orange Red, a New Zealand apple, might fill the first need. This variety was raised by crossing Cox's Orange Pippin with Delicious and since it has been on trial it has cropped more heavily than Cox.

The fruit is of medium size, $2\frac{1}{2}$–$2\frac{3}{4} \times 2\frac{1}{4}$ in., somewhat conical and not unlike Delicious in shape. The ground colour is lemon yellow up to three-quarters flushed with deep orange scarlet and a certain amount of broken striping, with patches of fine russet widespread over much of the fruit. The flesh is cream, firm, fine textured, sweet and of pleasant aromatic flavour. The stalk extends a little beyond the base of the fruit. Its natural season is November to February, keeping longer than Cox.

Tree growth is slightly more vigorous than Cox, somewhat upright to spreading, and spurring freely. When first grown in the trial this was a very clean skinned variety, but during the past few years the fruit has developed patches of dark russet giving it a "dirty" appearance when ready for market. This variety is described to emphasize how important it is to give a sufficiently long trial to bring to light all merits and faults.

A late apple showing some promise is Mutsu, a Japanese variety raised by crossing Golden Delicious with Indo. The fruit is medium-large, to large, rather

oblong, narrowing towards apex and slightly ribbed. The colour is bright green turning golden yellow with an occasional pale brown flush. The flesh is creamy white, crisp, juicy, sweet, somewhat reminiscent of Golden Delicious. The stalk is long, extending well beyond the base of the fruit.

Tree growth is very strong, spurring quite freely. During its short period of trial Mutsu has cropped consistently and the fruit has kept in excellent condition in cold store until the end of February. If its present promise is maintained it could become a commercial variety. It is a triploid and cross pollination will be necessary, but it flowers at the same time as James Grieve.

Pears

Although the number of new pears planted at Brogdale already exceeds the number received during the preceding thirty years, there is really no variety which at present shows commercial merit, although some of the trials are too recent to judge. This state of affairs is most disappointing because, with the disappearance of Laxton's Superb, an early pear is badly needed. Even more important, however, is that the pear industry is almost wholly dependent on Conference and, if anything were to happen to this variety, it would be a very serious loss. The only new variety which justifies mention at present is Merton Pride, raised at the John Innes Institute by crossing Glou Morceau with Double Williams'. The fruit is medium to medium large, broad conical to pyriform, even. The fruit is almost entirely covered with solid brown russet with the greenish yellow ground colour showing through in small patches and dots. The flesh is greenish white, very juicy and of good flavour. It ripens just after Williams'. Tree growth is moderately vigorous but cropping in the trial has so far been light. This is a triploid.

Cherries

Interest in cherries is at present somewhat small, probably because it takes a considerable number of years before they show a profit. In addition, tree losses from bacterial canker may be severe and make all the difference between a profit and loss. Virus free clones of a number of new varieties have been planted in the National Fruit Trials and every precaution is being taken to keep bacterial canker to a minimum. Two varieties are showing initial promise, but it will be some years before a full report can be issued on their behaviour.

Sue is a white cherry raised at Summerland, British Columbia. The fruit resembles Napoleon although it is not quite as large. It is a firm cherry of good quality and does not at present seem prone to cracking. It ripens a few days before Napoleon. Young trees have grown satisfactorily and its habit at present is good.

Van is a black cherry raised at the same station as Sue. The fruit is large, flattened heart shaped, shiny, attractive in appearance, firm and of good quality. Like Sue it has shown no proneness to splitting. Young trees are vigorous and of rather upright growth.

Plums

Most enquiries about plums are for early and late varieties. So far as early varieties are concerned, no new plum has been received for trial which is likely

to supersede Early Rivers. At the other end of the season there is no new plum which is likely to compete with Warwickshire Drooper, Laxton's Cropper and Marjorie's Seedling. There is, however, one late dessert plum which is attracting attention. This is Anna Späth which was discovered in Hungary nearly 100 years ago. The fruit is of medium size, oval-oblong, dark mahogany turning brownish purple, with many russet dots. The skin is thick, flesh olive green, firm, very juicy with a moderately rich flavour. Its season is mid- to late September. Anna Späth is a good grower; the tree is upright and spreading and has cropped freely in the trial. Unfortunately there is a prejudice against black plums for dessert, as this colour seems to be associated with cooking plums.

Amongst mid-season to late plums John Innes seedling No. 1455 raised by crossing Victoria with Coe's Violet is showing promise at present. The fruit is medium to medium large, oval-oblong with a golden ground colour flushed with carmine which tends to darken on becoming fully ripe. The skin is thick, the flesh yellow, firm, very juicy with rich flavour. Tree growth is spreading and moderately vigorous. It crops freely, but bullfinches have a liking for the buds. If it yields consistently, it may find a place as a red plum for marketing after Victoria.

Victoria is used in the trials as a control variety and in one of the units of eight trees planted for this purpose three have suddenly become late ripening, producing fruit which is not ready for picking a week to ten days or a fortnight after Victoria itself. If this mutation is fixed it should be a valuable acquisition for extending the Victoria season.

Soft Fruits

Amongst soft fruits the position is very much the same as with tree fruits, many new varieties not yet having completed their trial period, and it would be premature to make specific recommendations.

Growers are particularly interested in black currants and yet very few new varieties have been received for trial. In the present variety trial at Brogdale, only one new variety, Dereham 14, is showing promise. The bush is moderately vigorous, very compact in habit, with fruit trusses usually in two or three somewhat short racemes and berries of medium size. The fruit is quite well exposed, although there is some tendency to leafiness. Its short truss and the number of racemes per node do not make for easy picking. Cropping has been very good to date and it compares favourably with the standard Seabrook's Black.

One of the older varieties that is attracting some attention is the second early variety Raven. In some of our extended trials its cropping is as heavy or greater than that of other varieties of similar season. It makes a large cup-shaped bush. The fruit trusses are usually single and fairly long. The berries are medium to fairly large, with rather thin, tender skin. They ripen evenly and are easy to pick but do not hang too well.

The most recent introduction is the Long Ashton variety Tor Cross which fruited in the trial for the first time in 1962. It ripens about the same time as Mendip Cross but requires further trial.

Raspberry trials of established varieties such as Malling Promise, Malling Exploit and Malling Jewel have continued for several years. There are two new East Malling seedlings in the present trial but, as they are not yet released, it

would be premature to make comparisons. Anyone interested in these two seedlings can find brief descriptions in *Experimental Horticulture* 4.

A somewhat similar position exists amongst strawberries. A number of seedlings raised at the Scottish Horticultural Research Institute and at the John Innes Institute are at present undergoing trial, but it will take some years to determine their merits. However, one of the Scottish seedlings appears to be showing promise and may be released in a year or two.

One of the older varieties which is now receiving some recognition is Cambridge Rival, the stocks of which have been cleaned up and is producing heavy crops of attractive fruit. The fruit is large to medium-large, red turning dark red when fully ripe and must therefore be picked at frequent intervals. It is firm, juicy and of good quality. The plant is large to medium large and fairly open; it ripens about the same time as Royal Sovereign.

This is a brief summary of the varieties which, during the past year or two, have attracted the attention of growers and others, but only time will show whether they maintain their initial promise. However, anyone who would like more information on these varieties or others should write to the National Fruit Trials, or better still, visit them.

J. M. S. Potter

CORDON CUCUMBERS

The method of growing maincrop cucumbers on the cordon system has been known for many years, but it is only recently that reports from Scandinavia and the Netherlands have drawn attention to its extensive use in these countries. Cordon training is more suitable than the traditional system for narrow span Dutch light houses with high eaves and, although this type of glasshouse construction may have been primarily responsible for the adoption of this technique in Holland, growers there and in Denmark claim that high yields can be obtained with the minimum input of labour, which can be less skilled than is the case when plants are trained in the traditional manner on a canopy.

Cordon cucumbers are now being tried with success by a number of growers in England. At the Lee Valley Experimental Horticulture Station investigations are in progress to examine the method closely and thus assess the possibilities for it under conditions in Britain. Following an initial trial in 1961, when a satisfactory yield was obtained from a crop grown in this manner, a detailed investigation began in 1962 to compare the traditional and cordon systems under similar conditions for labour input, quality, earliness, total yield and gross monetary return.

Two crops have been grown this year and, though definite conclusions cannot be drawn at this stage, it may not be premature to discuss some of the results here.

Labour Input

Careful records of the time spent on training, trimming and watering have shown that labour input on an equivalent area basis has been almost identical for both systems. The requirement for individual cordon plants was less, but this was offset by the higher density of 6,000 plants per acre compared with 4,000

plants per acre on the traditional method. These densities were adopted as they are considered to be normal for these two techniques. The suggestion that there is a saving in labour may have come about because, on some Dutch nurseries three men will often undertake to maintain a hectare (2½ acres) of cordon plants for a fixed charge of about £55–60 per week. This cost is lower than that of traditional training in England but does not include all operations. On some nurseries water and fertilizers are applied through irrigation lines, and where this is done in combination with cordon growing, a saving in the region of £500 per acre per year could be brought about.

Yield and Gross Monetary Return

Cutting from the first crop commenced on 2 March, 1962, and at the end of the first month 32 plants on the traditional system had yielded 114 lb with a gross return of £12 6*s*. 0*d*., whereas 48 cordon trained plants, occupying the same glasshouse space, gave 164 lb and £17 16*s*. 0*d*. Thus the cordon system gave a materially higher yield over this period and it will be observed that the increase is closely related to the greater plant population mentioned above. With the second crop, from which cutting began on 10 August, the yield at the end of the first month, from a similar area of traditional trained plants was 366 lb and a gross return of £18 1*s*. 0*d*., compared with 413 lb and £20 12*s*. 0*d*. from the cordon plants. With the latter crop the smaller increase in favour of the cordon plants may have been due to the better light conditions giving quicker growth so that a greater plant density would then exert a smaller influence.

The first experiment was terminated on 4 July, 1962, and at that time the total yield from the traditional plants was 1,397 lb compared with 1,479 lb from the cordon trained plants. The gross monetary return showed a 9 per cent increase in favour of the cordon plants. With the second crop, terminated on 29 October, the yield from the traditional plants was 843 lb and from the cordon plants 909 lb. In this case the gross cash value showed an advantage of 7 per cent in favour of the cordon plants.

Management of Cordon Trained Plants

Before undertaking the production of cucumbers by the cordon method, it must be remembered that sufficient propagation space, pots and compost must be provided to raise the extra 2,000 plants required per acre. In addition, the older type of cucumber house 14-15 ft wide and with low eaves is unsuitable. If narrow houses are to be used, it is necessary for them to have high eaves to give sufficient height for training plants. On the other hand, wide houses with moderately high eaves are very satisfactory. At the Lee Valley Station houses 28 ft wide are used and the plants are arranged in rows along the length of the house, so that there is a single row under each eave and two double rows in the body of the house. The plants are 18 in. apart in the row and are trained towards the path at an angle of approximately 75° on strong sisal twine attached to a horizontal wire about 6 ft above the top of the bed. The main stem of each plant is twisted around the string until it reaches the wire, and is then trained along it a for a few inches before stopping. The stem is tied to the wire to prevent it slipping down the cord with the weight of fruit which will be carried in due course. The laterals are allowed to hang down the main stem and the lower ones

are stopped at one leaf, while those higher up are left with two leaves. Sub laterals on the lower part of the stem are pinched at one leaf and higher up they are allowed to retain 2–3 leaves. Hard pruning appears to reduce yields so the aim should be to maintain an adequate number of leaves on each plant. If foliage becomes too prolific as the season advances, laterals can be removed completely and those near the base of the plant may need to be cut out as soon as the first fruits are harvested, otherwise further extension growth will be so low that subsequent fruits will rest on or hang down the side of the bed.

In Holland and on some nurseries in England, growers adopt a different plant arrangement whereby the paths are narrower, but the plants are further apart in the rows so giving the same density. The best plant arrangement, the most suitable density and the correct balance between shoot and fruit growth to obtain maximum yield still await determination and, in view of the indications that cordon trained plants may have a shorter cropping period than those grown on the traditional system, further information is required on the most advantageous time to allow each crop to remain in the house. The investigations conducted so far indicate that, until such knowledge becomes available, the present methods of handling cordon trained plants appear to yield satisfactory crops and, though the system may not bring about a saving in labour, it is still worthy of consideration in its own right where suitable houses are available.

P. G. Allen

MUSHROOMS AT THE EXPERIMENTAL HORTICULTURE STATIONS

Experiments concerned with many aspects of mushroom growing are in progress at the Experimental Horticulture Stations. This report covers experiments carried out at Fairfield and Lee Valley and includes work on casing materials, spawning methods, rates of spawning, depths of compost and insecticides for control of mushroom insect pests.

Casing materials have been selected in order to try and discover a suitable alternative to peat and limestone or peat and chalk mixtures which may in certain circumstances soil the caps. At Fairfield, a mixture of limestone and $\frac{1}{2}$ in. coke breeze was compared with $\frac{1}{8}$ in. granite chips, and at Lee Valley materials now under trial are pea gravel, fine expanded clay aggregate and a gravel-chalk mixture. None of these materials has given consistently improved results when compared with peat and limestone or chalk mixtures. Different casing mixtures seem, however, to demand different rates and frequencies of watering. Future experiments are being designed to investigate the effect of frequency and amount of watering the casing when using materials with a low moisture holding capacity, but with an open well aerated structure.

At the Lee Valley Station the depth of compost used has been shown to have a very large influence on yield. In one experiment after 7 weeks cropping a 12 in. thick layer of compost yielded 43·3 oz per sq. ft of mushrooms compared with 23·2 oz per sq. ft in the case of a 6 in. layer.

The time of casing has been shown at Fairfield to have an effect on yield. Casing 14 days after spawning, when the mycelial patch on the surface of the compost was the size of a saucer, raised the yield by 15 per cent when compared with casing at full spawn run.

Investigations into spawning technique are in progress at Fairfield and Lee Valley and, although the series is not complete, certain information has been gained. The type of spawn used affects the performance of the subsequent crop; grain spawn giving a higher early yield than manure spawn. The amount of spawn applied per sq. ft affects the subsequent yield. With an additional spawn application ranging from $\frac{1}{2}$ to 4 oz per sq. ft, the yield after 7 weeks' cropping is increased. The yield after 11 weeks' cropping is most affected by an increase from $\frac{1}{2}$ to 1 oz per sq. ft; subsequent addition of spawn over the range 1 to 3 oz not being quite so effective. The method of mixing the spawn with the compost is also important. A comparison was made at Fairfield between through spawning, spot spawning and surface spawning. Through spawning gave the best yield followed by surface spawning, with spot spawning giving the lowest yield. It has been shown in previous work that through spawning is not the better method if any ammonia is left in the compost at spawning. So those who use this method to advantage must ensure that their compost is fully and adequately prepared. At the Lee Valley Station the super spawning technique has not been shown to be consistently better than through spawning.

Experiments at Fairfield on insect control have been concerned with the larvae of the midge *Mycophila speyeri*. An experiment was carried out to find the best method of incorporating aldrin in the casing layer to prevent the contamination of the caps by larvae. It was shown that an over-night soaking of one of the casing materials (3 bushels peat) in aldrin solution containing 1/7th fluid oz 30 per cent miscible aldrin in 21 gal of water, was the best treatment. The ground limestone being added after soaking. Other methods of application included, by power spray, by watering can and as a dust, but these were all inferior. For normal control, in practice, 2/7th fluid oz of 30 per cent miscible aldrin should be employed in 21 gal of water.

An experiment on the phytotoxicity of cecid control materials included BHC at 50 and 100 p.p.m. and two brands of aldrin at 50 p.p.m. It was shown that BHC at 50 or 100 p.p.m. did not depress the final yield of mushrooms. One of the brands of aldrin, however, was phytotoxic and it depressed the yield to a considerable degree, but the other brand had no such effect.

Investigations at Fairfield on the stage at which mushrooms are picked showed that this had an effect on the final yield. The later the stage of maturity at picking the larger the yield per sq. ft and the longer the time period between flushes.

J. B. Rothwell

STRAWBERRY FORCING

Forcing of strawberries in glasshouses has declined in popularity since the war, mainly because of the low yields obtained and the ever-increasing competition in the early strawberry market from imported fruit grown in the open in warmer climates.

However, the home-grown forced strawberry can command a premium price, as the quality of the fruit is generally superior to the imported product. The forced crop is still worth considering as a useful and profitable enterprise and, providing that an adequate yield can be obtained, a gross return of over 5*s*. per plant can be achieved, which compares favourably with the returns that can be realized from crops having similar requirements, e.g., pot chrysanthemums.

The variety traditionally used for forcing is Royal Sovereign, which gives good quality fruit, but only a relatively low yield. The varieties introduced during the past fifteen years or so have created a renewed interest in strawberry forcing, as several of these are capable of bearing very heavy yields when grown in the field. Cambridge Favourite, for example, has been forced by some growers, but the yields obtained have varied considerably some growers reporting complete success, others failure.

A considerable amount of research has been carried out in the Netherlands during the past two decades, and has provided some very useful information. But the results cannot be applied directly to circumstances in Britain as much of the work has related to frame crops, or to the forcing of varieties like Deutsch Evern, which are not usually regarded as satisfactory in this country as the quality of the fruit is too poor.

Work on the forced strawberry crop has recently begun at the Lee Valley and Stockbridge House Experimental Horticultural Stations. The results from the investigations at these centres, and from trials carried out at Ellbridge, have indicated that the most critical stage in the forcing of strawberry plants is at flowering time, for the success of the enterprise depends on pollination and the setting of sufficient fruits to give an economic yield. Different varieties vary considerably in the ease with which fruit set can be achieved. Those which are naturally early fruiting when grown outdoors tend to set fruit relatively easily when forced, but tend to give low yields. Some of the later varieties such as Cambridge Vigour and Cambridge Favourite could give heavy yields, but there is difficulty in obtaining good fruit set.

These problems are being studied in three ways:

1. a search for varieties which are capable of setting fruit and giving economic yields when forced;
2. a study of the possibility of using the low yielding varieties, which produce good pollen (e.g., Regina) to pollinate potentially heavy yielding varieties which cannot be depended upon to produce their own pollen. Cross pollination will have to bet carried out by hand, but as this is essential with early forced strawberries, it need not increase the cost of production significantly;
3. more fundamental studies of the environmental conditions which affect flowering, pollination and fruit set. Light and temperature are known to be particularly important.

J. Whetman

WEED CONTROL IN FLOWER CROPS

The interest and consequently the progress in this subject has not been as great as with vegetable crops and soft fruit. This can probably be explained by the fact that, with perhaps the exceptions of bulbs and anemones, most flowers are grown in considerable variety and in relatively small areas on any one holding. The use of herbicides is thus more involved and attended by greater risks as compared with treating relatively large areas of, say, onions or blackcurrants. The value of the flower crops in some cases might also deter a grower from using such materials until their safety and effectiveness is very well established. Experiments and observation studies designed to obtain information on these points and also on the economics of the practice have been carried out on Experimental Horticulture Stations.

The acreage of chrysanthemums grown in the open is considerable and weed

control by cultivation, particularly after stakes and other supporting material are placed in position, is expensive. Cresylic acid in its many proprietary forms is used by growers as a spray directed only on to the weeds and kills existing weeds by contact. This work must be done carefully as the spray will be equally damaging to the crop should it be applied to the foliage. Work on the Stations has shown that this material can be used among dahlias, if the same precautions are observed.

2,4-DES can be used as an overall spray on the above flower crops and on many others as it does not become active as a weedkiller until it is in contact with the soil. Experiments at Fairfield and Luddington have shown that, while it seldom does any damage to a crop (only two out of a large number of chrysanthemums have shown any ill-effect), its effectiveness largely depends on weather conditions. It is at least effective when the weather is dry and cold and most effective when moist and humid, under which conditions and when applied to clean ground germinating weeds will be killed over a period of 4–6 weeks.

Simazine at 1 lb active ingredient per acre applied within one week of planting has proved the most effective treatment among dahlias at Fairfield. This material, which is held in the top inch of soil, persists for a considerable time and further work may bring to light other perennial crops amongst which it can be safely used. From experiments at the Lee Valley Experimental Horticulture Station it would seem that peonies, pyrethum and Michaelmas daisies are in this category, but some damage was noted on *Chrysanthemum maximum* variety Esther Read and scabious. Simazine has also shown promise when applied at 1 lb per acre to transplanted wallflower, but the work at Rosewarne will have to be confirmed by further experiments before any recommendations can be made.

The treatment of annual flower crops has not shown up any safe treatment. Results have not always been consistent, but it is obviously difficult to use a herbicide on seed which has usually a very light covering of soil.

Chemical weed control among flower crops presents many problems, but the work at the stations and at research establishments is gradually producing evidence of how they can be used effectively and economically.

A. D. Harrison

New Items of Interest in the Experimental Programme

CONTINUOUS CEREAL GROWING

Some aspects of intensive cereal growing have been studied on the Husbandry Farms in recent years but, in view of the great importance of the subject, a new series of trials has been started to examine the trends in yields of wheat or barley when grown on the same land continuously. To cover a range of seasonal conditions, provision is being made for different plots to enter the continuous cereal sequence in each of the six years 1963–68. In all cases, the preparatory crops will have been such as to minimize the cereal pest and disease situation at the time of growing the first cereal crop. The tests are being carried out at four levels of nitrogenous manuring, ranging from nil to 90 units per acre for spring barley, 100 units per acre for spring wheat and 160 units per acre for winter wheat.

In addition to yield data, information will be obtained on changes in soil condition and the developments, if any, of pest and disease factors.

Spring barley is the subject of study at Bridget's and Gleadthorpe; winter wheat at Boxworth, High Mowthorpe and Rosemaund; and spring wheat at Bridget's.

HIGH MOISTURE BARLEY

Pioneer work in France and the United States and more limited experience in this country has shown that undried barley or other cereal grain can be stored in bulk provided that the bin or silo is sealed to make it airtight. Under these conditions, the air in the grain mass or occupying the unfilled volume of the silo loses its oxygen and carbon dioxide is produced which inhibits the mould organisms and preserves the grain. As a result of fermentation, a little alcohol or breakdown products from alcohol are also formed.

This method of storage saves drying costs. At harvest the pace of combining is not limited by the capacity of the drier as is often the case. Another advantage is that the digestive upsets to cattle, that may result from feeding meals ground or rolled from dry cereal, are avoided by crushing the grain at about 18 per cent moisture to produce a flaky and dust free feed.

At Gleadthorpe Experimental Husbandry Farm in 1962, barley was stored in two airtight bins made of steel plate coated on both sides with glass, each holding 60 tons of grain. One bin was filled with barley at 18 per cent moisture and the other with grain at 24 per cent moisture. The grain came straight from the combine in trailers, tipping into a hopper near the silo from which it was conveyed by auger to the central filling hole at the top of the bin. The crops had been sprayed with selective herbicide and no pre-cleaning was necessary. The "24 per cent" bin was filled in 2½ days but, owing to catchy weather, filling the "18 per cent" bin took 13 days.

Evidence from thermocouples in the bins showed that the rise of temperature in the grain mass was quite small; the maximum temperature recorded was only 80°F (26°C).

Six weeks after filling and sealing, the first withdrawals were made from both bins using the bottom unloaders which auger the grain from the centre of the mass. The first lot of grain stored at 18 per cent moisture came out in excellent

condition and remained so during the next four weeks, when it was either ground in a hammer mill for poultry rations, or rolled for feeding to calves on an intensive concentrate diet. The barley stored at 24 per cent moisture came out rather darker in colour and with a pronounced, though quite agreeable, alcoholic smell.

Keeping quality of the high moisture grain after withdrawal varied to some extent; in the earlier withdrawals, deterioration appeared to set in after two or three days, but later in colder weather the grain kept in good condition for up to a week.

The high moisture grain generally flowed freely through the unloading auger, although on one or two occasions bridging caused a temporary stoppage. At 24 per cent the grain was rolled satisfactorily though it could not be ground.

The cost of storage in these bins is about £14 per ton and there are no drying costs. As a method of storing grain for home consumption at 18–19 per cent moisture it seems quite satisfactory but, when stored as wet as 24 per cent, barley is more difficult to handle and the fate of the last few tons in the bin is still unknown. The critical time will be when no more grain will flow to the bottom unloader and the doors of the silo have to be unsealed to prepare the sweep auger for clearing out the remainder. Some air is likely to enter the bin at this time and, should trouble occur, it may be necessary to empty the bin and dry by conventional means. So far as feeding is concerned, the cattle have done well on rolled high moisture grain in spite of its alcoholic flavour, and no scouring has occurred when fed to 2-year-old bullocks at 10 lb per head per day as a supplement to silage.

In most seasons, combining at 18–19 per cent moisture is a reasonable aim. It is during the period when the crop is left standing to dry down to 14–16 per cent moisture that most of the losses from shedding and wind damage occur. Losses from these causes are not generally appreciable during the earlier stages of ripening between 24 and 18 per cent and, although early harvesting of a proportion of the acreage at 24 per cent moisture helps to speed the harvest, this advantage is likely to be outweighed by the greater inconvenience of handling the very damp grain afterwards and the smaller margin of safety.

SLUG CONTROL

On most soil types, slugs are a horticultural rather than an agricultural pest. On heavy silt and certain clay soils, slugs can cause crop failures of winter wheat and very serious financial losses to the potato grower. Work on this problem has been proceeding for many years in the Eastern Region and falls into three categories:

a identification of the species and investigations into their biology;
b determination of the extent of the problem, largely by survey;
c a search for chemical and other control techniques.

Terrington Experimental Husbandry Farm is co-operating with the Advisory Entomologists and the new Agricultural Research Council Unit at Rothamsted in this work. The Terrington Farm includes heavy silt soil on which the pest is particularly troublesome.

COMPARISON BETWEEN PERMANENT AND TEMPORARY GRASS ON A FARM UNIT BASIS

Comparisons have been made between production from permanent and temporary grass since 1952 at Great House Experimental Husbandry Farm. Initially, measurements were made from sample cuts on plots given the same management and manurial treatment. They showed that the permanent grass, over a period of five years, gave a higher yield of dry matter. This trial was followed by comparisons made on a field scale where measurements were taken in terms of livestock production. Over a period of four years similar results were obtained.

In order to study the problem on a complete farm enterprise, a new experiment will commence shortly. Buckden Farm, a holding of approximately 80 acres, has been farmed as a part of Great House Experimental Farm for some years. It has now been divided into two 40-acre holdings which will be farmed quite separately, one on a permanent grass system and the other on a long ley system. The management, manuring and labour will be common to both holdings, but otherwise each will be farmed as a separate economic unit.

Over a period of years, the total input and output figures should provide invaluable information on economic trends and relative productivity.

BARN DRYING OF CHOPPED HAY

With the current emphasis on cutting labour costs and the successful application of portable fan units for barn drying of hay, a logical development is the drying of hay at the site at which it will be fed in winter. This storage drying has been done by many farmers though the hay has been chiefly in the form of bales. In the U.S.A. and on the Continent, attention has been given to drying loose hay chopped into short lengths, storing it and then allowing cattle to self-feed or feeding them by means of augers emptying the hay into troughs. In this sort of system, the hay "flows" from field, to barn, to beast. The cost of baling and bale handling is eliminated, but other new machinery is involved and most of it is expensive. The crop has to be cut, conditioned in the field, picked up, chopped and blown into a self-emptying trailer. From the trailer it has to be blown into a storage/drying box and then dried. As with barn drying of baled hay, the secret of economic success is to bring the crop down to a low moisture content in the field as quickly as possible. The cost of drying rises sharply as the moisture content at carting increases.

The box is filled in two or three layers with an interval of a few days between, at the same time aerating the hay continuously until it is safe to store.

At Drayton in 1962, a study was made of this method of making hay and, though there have been snags, the processing and feeding of it have been remarkably successful. One bay of a Dutch barn type structure was sheeted in with corrugated iron. A welded, mesh floor was made, supported on concrete blocks and railway sleepers, about 2 ft above the floor of the building. A portable diesel engine-driven fan unit was applied to one side of the box thus formed.

The herbage was mown, crimped and then turned for two days in the field. It was picked up by a double chop, reel pick-up forage harvester, adjusted to give a 4 in. chop.

Because of favourable drying conditions in the field, the box was filled in two stages with material between 20 and 30 per cent moisture content. Only five days aeration was required and nearly 11 tons of hay were made at a fuel cost of 8*s.* 7*d.* per ton.

In the autumn, one course of corrugated sheet was removed from the bottom of the hay box, along one side. This side is adjacent to a cattle yard and Norwegian type hay troughs had been let into the hay box before filling. The chopped hay was extremely firm and the face so stable that it had to be loosened before the cattle could feed.

For a day or two they self-fed, after that hay was forked down as required into the feeding troughs from above. Feeding therefore required very little labour.

The results of this first year's work have been extremely promising and the study will continue, paying particular attention to economic aspects.

BEEF FROM YOUNG BULLS

There are indications from the Continent and results from limited trials at the Rowett Research Institute which suggest that the rate of liveweight gain of entire males is some 10 per cent higher than that of steers. However, almost all the experience to date has been with individually-tied stall-fed bulls. Several Husbandry Farms are taking part in an investigation to compare the performance and behaviour of contemporary groups of yard-fed bulls and steers. These animals will be fed intensively for slaughter at under 15 months of age. In addition to providing information on the relative rates of liveweight gain, the trials will show up any management or handling problems arising from the group feeding of entire males.

INTENSIFICATION OF SHEEP

During the last few years at Bridget's Experimental Husbandry Farm, ewe and lamb summer and winter management experiments have been carried out for the appropriate season of the year only. In an effort to combine the results of these experiments and to study the possibilities of greater intensification, three all-the-year-round sheep farmlets are being started during the autumn of 1962.

A farmlet will receive nitrogen at 50, 150 or 250 units per acre per annum, applied at intervals during the grazing period, plus an adequate dressing of phosphate and potash. It is hoped that the corresponding rates of stocking will be 3, 4 or 6 ewes per acre all the year round. Summer feed will be grass managed on a forward creep grazing system, while winter feeding will be mainly silage supplemented with hay, conserved from each farmlet. To do this, the grass on half of each unit will be conserved, which means that for part of the summer at least, the stocking rate on the creep grazing paddocks will be 6, 8 or 12 ewes and their lambs per acre.

During the spring and summer of 1962, the intermediate nitrogen treatment was given a pilot run. Sixty ewes and 94 lambs were put on the unit ($7\frac{1}{2}$ acres) as they lambed, between 13 March and 14 April. This gave a stocking rate of 8 ewes and their lambs per acre. Spring was extremely late and it was necessary to feed hay at 2 lb per head per day for the first three weeks, while the sheep grazed round the creep paddocks for the first time. The stock had to be taken off

for a further week before the second grazing cycle began. During late June and early July, keep became very short. The lambs were weaned and the creeps given another rest for 12 days. During this period, supplementary grazing would normally be available on the silage aftermaths.

Apart from one that died, all lambs were sold fat, the last bunch going on 10 September. The average liveweight gain was 0·55 lb per day from birth to slaughter, giving a total production per acre of 898 lb of live weight.

CONDITIONING OF BULBS FOR FLOWER PRODUCTION

There is no true resting stage in the annual growth cycle of bulbs. Even while they are in store, dry and apparently dormant after lifting in summer, the embryo flower buds are developing. In fact this is the period of greatest activity within the bulb. The conditions, especially the temperature under which bulbs are stored, greatly influence their internal development and the following year's flower crop.

Temperature treatments during storage can be used to produce flowers out of normal season in the open ground, especially for very early narcissus crops in the south west, or they may be used for "retarded" crops in Lincolnshire and elsewhere, but conditioning treatments are of greatest value to bulb forcers. Since the early 1920s observant growers and advisers in the bulb districts have been using storage treatments to condition bulbs for earlier forcing and to get more consistently good results in that technique. About 3/5ths of the forced bulbs flowers grown in England and Wales are produced in Holland, Lincolnshire, from locally grown bulbs. Most of the growers in this part of the country follow Dutch recommendations on conditioning and storage. The results obtained are generally good, but each season some failures and problems associated with storage treatment and lack of proper knowledge are met with.

To provide facilities for work on this subject, a number of temperature-controlled cabinets and chambers were installed at Kirton in 1962, though not completed in time to allow precise experiments that season. The cabinets and stores are capable of accurately maintaining any required temperature in the range of 25 to 120°F (—°4 to 49°C) and any required humidity between 50 per cent and 93 per cent. Temperatures between 28 and 96°F (—°4 to 36°C) are in commercial use. Forcing houses have now been built and are being used to test the effect of the storage treatments given to the bulbs. This work will be closely linked with bulb research being planned at the Glasshouse Crops Research Institute and with experimental work on bulb storage at Rosewarne.

ENRICHMENT OF THE GLASSHOUSE ATMOSPHERE WITH CARBON DIOXIDE

Carbon dioxide is the raw material from which a plant builds up its organic constituents and is therefore an essential requirement for crop growth. Even in the open with leafy crops it is believed that growth is often limited by a shortage of CO_2; and under glass where the concentration which is maintained depends on the efficiency of ventilation the problem is sometimes acute. Plant physiologists had often discussed means of raising the concentration but such methods as the feeding back of flue gases into the house had so far never been

practical. Methods of introducing carbon dioxide into glasshouses at economical prices have now become available.

Some preliminary studies have been undertaken at the Lee Valley Experimental Horticulture Station and the results are in line with experience in other countries. The indication is that, during the winter months, the growth of leafy plants, such as lettuce and certain flower crops, may be materially improved. The experiments are being continued and expanded.

Experimental Husbandry Farms and Horticulture Stations

Centre	*Acreage*	*Main Farming and Experimental Activities*
HUSBANDRY FARMS		
Boxworth E.H.F., Boxworth, Cambs.	849	Mixed farm on boulder clay. Friesian cattle, cross bred ewes and Large White pigs. Rearing and feeding dairy stock: arable crops including control of wild oats: silage making.
Bridget's E.H.F., Martyr Worthy, Winchester, Hants.	1,035	Large scale arable farm with leys on chalk. Ayrshire herd, Clun flock and Landrace pigs. Management and feeding of dairy stock, growing cereal crops, growth of leys and conservation.
Drayton E.H.F., Alcester Road, Stratford-on-Avon, Warwickshire.	470	Mixed farm on Lias clay. Beef cattle feeding: cross bred ewes. Utilization of grassland for beef and lamb production: grass conservation.
Gleadthorpe E.H.F., Welbeck Colliery Village, Mansfield, Notts.	493	Light sand arable farm. Rearing Friesian steers. Poultry. Production of arable crops: irrigation: maintenance of fertility: feeding and management of laying poultry.
Great House E.H.F., Helmshore, Rossendale, Lancs.	432	High lying Pennine farm in industrial area. Ayrshire cattle, Derbyshire Gritstone sheep, Large White pigs: poultry: management of dairy cattle: production, utilization and conservation of grass. Rearing and housing of laying hens.

Centre	*Acreage*	*Main Farming and Experimental Activities*
High Mowthorpe E.H.F., Duggleby, Malton, Yorks.	1,080	Arable farm on high lying chalk. Cross bred beef cattle: cross bred ewes: Large White pigs. Production of cereal and root crops: rearing and feeding of cattle and sheep.
Kirton and Terrington E.H.Fs., Terrington St. Clement, King's Lynn, Norfolk.	304	Two silt farms run together. Large White and Essex pigs. Production of arable crops including cereals, potatoes, sugar beet, vegetables and soft fruit, also bulbs for forcing and tomatoes under glass. Pig breeding and management.
Liscombe E.H.F., Dulverton, Somerset.	495	Upland grass farm adjoining Exmoor. North Devon cattle: Clun and cross bred sheep. Breeding and rearing of cattle and lambs: production of grass and fodder crops.
Pwllpeiran E.H.F., Cwmystwyth, Aberystwyth, Cards.	3,000	Welsh mountain farm. Welsh sheep and Welsh Black cattle. Management of cattle and sheep: provision of winter fodder: shelter.
Rosemaund E.H.F., Preston Wynne, Hereford.	436	Mixed farm on heavy Red Sandstone soil. Hereford and cross bred cattle, cross bred sheep. Breeding and management of beef and beef × dairy cattle. Production of arable crops and hops.
Trawscoed E.H.F., Trawscoed, Aberystwyth, Cards.	920	Mixed farm on shale type soils with moor. Friesian cattle: Welsh and Half-bred sheep: Welsh pigs. Rearing and feeding dairy stock: growth and utilization of leys: breeding and management of sheep and pigs.

HORTICULTURE STATIONS

Efford E.H.S., Lymington, Hants.	376	Nutrition and variety trials with top and soft fruit: vegetables including potatoes: tomatoes and other crops in heated and cool glasshouses: flower crops: irrigation.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Fairfield E.H.S., Greenhalgh, Kirkham, Preston, Lancs.	22	Glasshouse crops including tomatoes, lettuce: flowers: mushrooms: black-currants and raspberries.
Lee Valley E.H.S., Ware Road, Hoddesdon, Herts.	26	Glasshouse crops including tomatoes, cucumbers, lettuce, chrysanthemums: flowers in the open: mushrooms: mobile glasshouses.
Luddington E.H.S., Stratford-on-Avon.	230	Apples, plums and soft fruit pest and disease control, nutrition and rootstocks: vegetables and flowers: mobile glass-houses: irrigation: weed control.
Rosewarne E.H.S., Camborne, Cornwall.	109	Early bulb and vegetable crops including potatoes: mobile glasshouses: shelter.
Ellbridge E.H.S. (Sub-Station), Hatt, Saltash, Cornwall.	5	The study of early crops produced in the Tamar Valley.
Stockbridge House E.H.S., Cawood, Selby, Yorks.	161	Vegetable crops including rhubarb. Top and soft fruit: fixed and mobile structures: shelter: mushrooms: flowers.
National Fruit Trials, Brogdale Farm, Faversham, Kent.	185	Testing and classification of all types of top and soft fruit.
Cleppa Park E.H.S., Newport, Monmouthshire.	68	Production of fruit, vegetable and flower crops under local conditions, in the open, under Dutch lights and cloches, and in glasshouses.

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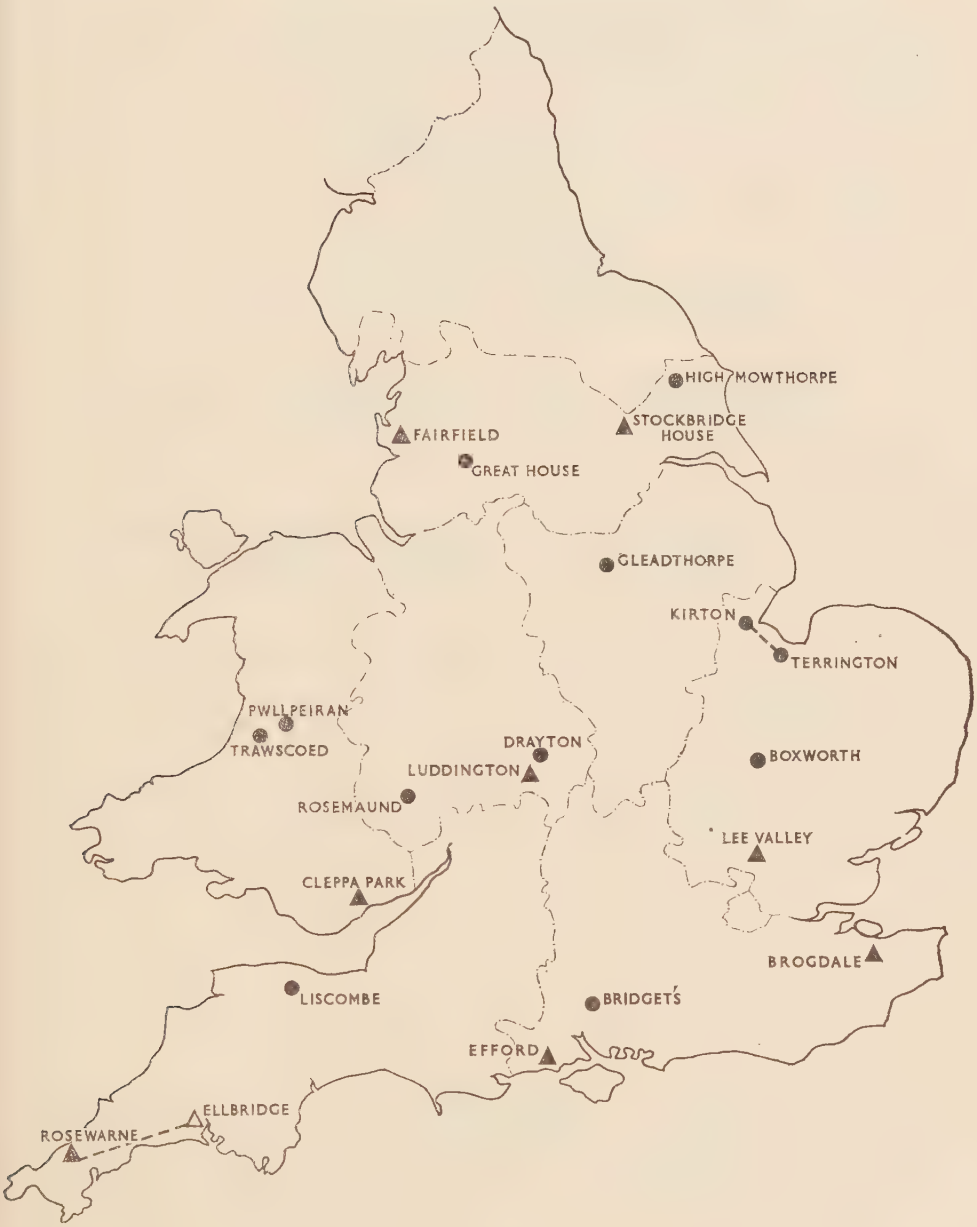

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